**HAZARD RANKING SYSTEM (HRS)**
**DOCUMENTATION RECORD - REVIEW COVER SHEET**

Name of Site: Jackpile-Paguate Uranium Mine

EPA ID No.: NMN000607033

Contact Persons

| | | |
|---|---|---|
| Site Investigation: | Brenda Nixon Cook, NPL Coordinator, EPA Reg.6 (Name) | (214) 665-7436 (Telephone) |
| Documentation Record: | Brenda Nixon Cook, NPL Coordinator, EPA Reg.6 (Name) | (214) 665-7436 (Telephone) |

Pathways, Components, or Threats Not Scored

1) Ground Water Pathway: The ground water migration pathway has not been scored because although there is analytical data to support a release, there is not a sufficient number of targets to impact the site score. Based on information available at this time, evaluation of the ground water migration pathway would not affect the listing decision.

2) Ground Water to Surface Water Pathway: The ground water to surface water pathway has not been scored because although ground water in the Jackpile Sandstone interchanges with water in the Rio Moquino and Rio Paguate through unconsolidated alluvium deposits along the stream channels, the overland flow component score was sufficient for site listing**.**

3) Soil Exposure Pathway: The soil exposure pathway has not been scored. Based on information available at this time, evaluation of the soil exposure pathway would not affect the listing decision.

4) Air Pathway: The air migration pathway has not been scored. Based on information available at this time, evaluation of the air migration pathway would not affect the listing decision.

5) Surface Water Pathway: The drinking water and environmental threats have not been scored. Based on information available at this time, evaluation of the drinking water and environmental threats would not affect the listing decision.

# HRS DOCUMENTATION RECORD

| | |
|---|---|
| Name of Site: | Jackpile-Paguate Uranium Mine |
| Site Spill Identifier No.: | A6T3 |
| CERCLIS Site ID No.: | NMN000607033 |
| EPA Region: | 6 |
| Date Prepared: | March 2012 |
| Street Address of Site: | SR279 near Paguate, Laguna Pueblo |
| City, County, and State: | Paguate, Cibola County, New Mexico 87040* |
| General Location within the State: | The site is located near the city of Paguate, Cibola County, New Mexico. Paguate is located in the Laguna Indian Reservation approximately 40 miles west of Albuquerque (Ref. 3, p. 1). |
| Topographic Map(s): | The following U.S. Geological Survey (USGS) 7.5-minute topographic series map was used in locating the site: Moquino, New Mexico (1957) (Ref. 3, p. 1). |
| Latitude*: | 35° 8’ 1.42” North |
| Longitude*: | 107° 20’ 50.54” West |

Latitude and Longitude coordinates were measured at the point of convergence of Rio Paguate and Rio Moquino near the center of the former mine and were determined using a scaled aerial photograph and ESRI ArcMap software (Ref. 9, p. 1).

Scores

| | |
|---|---|
| Air Pathway | Not Scored |
| Ground Water Pathway | Not Scored |
| Soil Exposure Pathway | Not Scored |
| Surface Water Pathway | 100.00 |
| **HRS SITE SCORE** | **50.00** |

*The street address, coordinates, and contaminant locations presented in this HRS Documentation Record identify the general area in which the site is located. They represent one or more locations EPA considers to be part of the site based on the screening information EPA used to evaluate the site for NPL listing. EPA lists national priorities among the known "releases or threatened releases" of hazardous substances; thus, the focus is on the release, not precisely delineated boundaries. A site is defined as where a hazardous substance has been "deposited, stored, placed, or otherwise come to be located." Generally, HRS scoring and the subsequent listing of a release merely represent the initial determination that a certain area may need to be addressed under CERCLA. Accordingly, EPA contemplates that the preliminary description of facility boundaries at the time of scoring will be refined as more information is developed as to where the contamination has come to be located.

**NOTES TO THE READER**

1. The following rules were applied when citing references in this documentation record:

   Tracking numbers are assigned by the region to every page of every reference. The tracking number consists of the reference number followed by the page number within that reference. A tracking number has a two-digit number followed by the sequential number (e.g., Reference 4, page 1 is expressed as 040001 in Reference 4).

2. Hazardous substances are listed by the names used in the January 2004 Superfund Chemical Data Matrix (SCDM) (Ref. 2).

3. Attachment A of this document record consists of the following figures:

   - A-1 Site Location Map
   - A-2 Site Layout Map
   - A-3 Surface Water Pathway
   - A-4 15-Mile Target Distance Limit
   - A-5A Site Inspection Sample Location Map
   - A-5B Expanded Site Inspection Sample Location Map

## REFERENCES CITED


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## SITE SUMMARY

The Jackpile-Paguate Uranium Mine site is located on the Laguna Indian Reservation about 40 miles west of Albuquerque in Paguate, Cibola County, New Mexico (Ref. 3, p. 1; Ref. 4, p. 21). The property is located in an area of canyons and arroyos to the east of the village of Paguate as seen on Figure A-1 (Ref. 3, p. 1). The former uranium mine facility encompasses approximately 7,868 acres and includes the following sources: open pits and waste dumps. Overburden and ore-associated waste was stockpiled within the mine area, stockpiled in an adjacent river's (Rio Moquino) floodplain, or placed in the mined-out areas of the pits as backfill (Ref. 4, pp. 21, 69). The sources at the property (the open pits, and the waste dump) contain hazardous substances that have released into the surface waters of Rio Paguate, and Rio Moquino via the surface water pathway (described below). These releases of hazardous substances have caused Level II contamination within fisheries identified within the Rio Paguate and Paguate Reservoir.

For the purpose of this HRS Documentation Record, the "property" is defined as approximately 2,656 acres of the facility which were disturbed and contained three open pits that were between 200 and 300 feet deep, 32 waste dumpsand 23 protore stockpiles (Ref. 4, p. 24; Ref. 5, p. 184). A Site Layout Map is provided as Figure A-2 and the locations of the disturbed areas can been found in References 28 and 29. The mine was operated by Anaconda Minerals Company, a division of Atlantic Richfield Company. Mining operations were conducted from 1953 through early 1982. The mine was closed because of depressed uranium mining conditions. During the 29 years of mining, approximately 400 million tons of rocks were moved within the mine area and approximately 25 million tons of uranium ore were transported via the Santa Fe Railroad from the mine to Anaconda's Bluewater Mill, approximately 40 miles west of the property (Ref. 4, p. 21; Ref. 5, p. 11).

The town of Paguate is located adjacent and west of the property with a population of approximately 492 according to the 2000 census (Ref. 3, p.1; Ref. 16, p. 1). The remaining surrounding area is mainly undeveloped, and a varied topography that contains wildlife consisting of elk, antelope, goats, and mule deer. There is also a population of approximately 1,500 domesticated cattle on the Laguna Reservation (Ref. 3, p.1; Ref. 19, pp. 6, 7). As depicted on a USGS topographic map of the area, the perennial rivers Rio Moquino and Rio Paguate flow through the property boundary and the two rivers merge near the center of the property (Ref. 3, p. 1, Figure A-2). According to Laguna officials, contaminated source material is present along the river bank and would be in direct contact with the sources when the river is flowing (Ref. 19, pp. 4, 6, 7). The Rio Moquino flows southeasterly into the Rio Paguate within the property and the Rio Paguate continues to flow south of the property through the Paguate Reservoir and then becoming the Rio San Jose (Ref. 3, pp. 1 to 3). There is documentation of fishing occurring within these perennial rivers and that the fish are used for human consumption (Ref. 23, Ref. 41).

In December 1986, under a series of agreements between the Bureau of Indian Affairs (BIA) and the Pueblo of Laguna, it was agreed that the Pueblo of Laguna would perform the management, coordination, and administration of the Jackpile-Paguate Reclamation Project in accordance with the requirements set forth in the Jackpile-Paguate Environmental Impact Statement (EIS) and the associated Record of Decision (ROD) (Ref. 5, p. 184).

Reclamation of the Jackpile-Paguate Uranium Mine commenced in 1990. The "preferred alternative" reclamation plan incorporated the following: backfilling of the open pit areas to at least 10 feet above projected ground water recovery levels using protore and waste rock dump material; slope reduction of the upper 15 feet of highwall slopes; recontouring and covering of remaining waste rock dumps; completion of arroyo drainage improvements and erosion controls; decontamination of those structures to remain, and removal/disposal of all non-essential structures; plugging and bulkheading of underground ventilation raises and decline portals, respectively; reclamation of miscellaneous features such as wells, access roads, rail spurs, drill holes, etc.; property-wide revegetation of disturbed areas; and provision of property security and long-term monitoring of reclamation success for a period of not less than 10 years (Ref. 5, p. 12).

On 10 June 1995, the Laguna Construction Company, who was in charge of the reclamation, officially closed out the Jackpile Reclamation Project (Ref. 6, p. 57).

In September 2007, a ROD Compliance Assessment for Jackpile-Paguate Uranium Mine was completed by OA Systems Corporation to determine if the post-reclamation had met the requirements of the ROD. This report concluded that reclamation of the mine was still not complete as several non-compliant and potentially non-compliant issues still needed to be addressed (Ref. 5, pp. 80 to 92). The mine would be considered complete when revegetated sites reached 90 percent of the density, frequency, foliar cover, basal cover, and production of undisturbed reference areas (but no sooner than 10 years following seeding) (Ref. 5, p. 92).

As part of the ROD Compliance Assessment, surface water data were evaluated for 10 years between 1996 and 2006 (Ref. 5, p. 191). During this evaluation, several samples were found to exceed EPA Maximum Contaminant Levels (MCLs) for drinking water for total uranium at 0.03 milligram per liter (mg/L) and National Secondary Drinking Water Standards of 0.05 mg/L for manganese (Ref. 5, pp. 200 to 202). The following concentration ranges were found in samples collected during this timeframe:

| Location | Total Uranium Concentrations mg/L | Manganese Concentrations mg/L | Reference |
|---|---|---|---|
| Rio Paguate – Ford Crossing-Rail Trestle | 0.08 - 544.14 | <0.01 - 10.7 | Ref, 5, p. 191, Ref. 14, p. 6 |
| Lower Rio Moquino | 0.03 - 234.95 | 0.0089 - 0.127 | Ref, 5, p. 191; Ref. 14, p. 7 |
| Lower Rio Paguate | 0.016 - 163.25 | 0.0357 - 0.13 | Ref, 5, p. 191; Ref. 14, p. 8 |
| Paguate-Moquino Confluence | 0.029 - 252.59 | 0.0112 - 0.14 | Ref, 5, p. 191; Ref. 14, p. 9 |
| Upper Rio Moquino | 0.008 - 52.89 | <0.01 - 0.036 | Ref, 5, p. 191; Ref. 14, p. 10 |
| Upper Rio Paguate | 0.002 - 32.21 | 0.0396 - 0.146 | Ref, 5, p. 191; Ref. 14, p. 11 |
| Paguate Reservoir | 0.002 - 17.42 | <0.01 - 0.004 | Ref, 5, p. 191; Ref. 14, p. 12 |

Note:
< - Less Than

As part of the Water Pollution Program Grants (Section 106), the Pueblo of Laguna Environmental and Natural Resources Department has been collecting surface water samples along the surface water pathway quarterly from 2005 through 2009 (Ref. 30, p. 39). The samples have been analyzed for total uranium (Ref. 27, p. 23). As with the samples collected as part of the ROD Compliance Assessment, these samples also contain concentrations that exceed the EPA MCL of 0.03 mg/L or 30 micrograms per liter (ug/L). The following concentration ranges were found in the samples collected:

| Location | Total Uranium Concentrations ug/L | Reference |
|---|---|---|
| RPG-03<br>Rio Paguate below the former Jackpile-Paguate Mine (within the TDL) | 0.007 - 452.557 | Ref. 27, pp. 23, 43 |
| RPG-04<br>Rio Paguate at Mesita Dam (within the TDL) | 0.167 - 217.45 | Ref. 27, pp. 23, 43 |
| RSJ-04<br>Rio San Jose below the Dipping Vat Spring on Sedillo Grant (beyond the TDL) | 2.012 - 21.615 | Ref. 27, pp. 23, 43 |
| RMQ-01<br>Rio Moquino above Jackpile-Paguate Mine (background) | 0.005 - 31.138 | Ref. 27, pp. 23, 43 |

These results indicate contamination within the surface water pathway, but according to the ROD Compliance Assessment, several data gaps remained and it was recommended that further monitoring and evaluation be performed (Ref. 5, pp. 204 to 206).

Post-reclamation land uses for the property include limited livestock grazing, light manufacturing, office space, mining, and major equipment storage. Specifically excluded are habitation and farming (Ref. 5, p. 79).

Based on analytical results from the Site Inspection (SI) conducted in March 2010 (whose results are presented in this HRS Documentation Record), there is an observed release of uranium$^{234}$, uranium$^{235}$, uranium$^{238}$ [the main components of total uranium] and manganese to Rio Paguate, Rio Moquino and the Paguate Reservoir (Ref. 30, pp. 42, 43). This release resulted in Level II contamination of two fisheries within the Rio Paguate and the Paguate Reservoir, extending approximately 5.43 miles downstream from sample locations RM-JM-SW and RP-JM-SW within the surface water migration pathway (see Section 4.1.3.3).

The EPA decided to complete an Expanded Site Inspection (ESI) of the Site in January 2011. As part of the ESI, a draft Conceptual Site Model (CSM) was prepared based primarily on the data and conclusions of the SI and other historical facility reports. The purpose of the CSM was to compile the existing hydrologic and geochemical data for the property (Ref. 35, p. 2). Based on the CSM, it was concluded that ground water and surface water are in hydrologic communication across the property

Hydrologic observations and modeling indicate that pit waters present on the property are not contained and flow into the surface water system via ground water pathways, carrying contaminants into that system (Ref. 35, p. 2795). Chemical data also suggest that reactions in the backfilled pits, and subsequent migration to ground water, may be shifting the chemistry of surface water at, and below the property (Ref. 35, p. 2795).

In April 2011, ESI sampling activities were conducted. ESI sampling activities focused on both ground water and surface water sampling. Analytical results from the ESI (whose results are presented in this HRS Documentation Record) document an observed release of isotopic uranium, and manganese to the surface water pathway (Ref. 35, pp. 3, 30, 33).

## WORKSHEET FOR COMPUTING HRS SITE SCORE

| | | S | $S^2$ |
|---|---|---|---|
| 1. | Ground Water Migration Pathway Score ($S_{gw}$) (from Table 3-1, line 13) | NS | NS |
| 2a. | Surface Water Overland/Flood Migration Component (from Table 4-1, line 30) | 100 | 10,000 |
| 2b. | Ground Water to Surface Water Migration Component (from Table 4-25, line 28) | NS | NS |
| 2c. | Surface Water Migration Pathway Score ($S_{sw}$) (Enter the larger of lines 2a and 2b as the pathway score) | NS | NS |
| 3. | Soil Exposure Pathway Score ($S_s$) (from Table 5-1, line 22) | NS | NS |
| 4. | Air Migration Pathway Score ($S_a$) (from Table 6-1, line 12) | NS | NS |
| 5. | Total of $S_{gw}^2 + S_{sw}^2 + S_s^2 + S_a^2$ | ---- | 10,000 |
| 6. | HRS Site Score: Divide the value on line 5 by 4 and take the square root. | | **50.00** |

Notes:

S Score
$S^2$ Score squared
NS Not scored

Tables 3-1, 4-1, 4-25, 5-1, and 6-1 refer to score sheets presented in the HRS (Ref. 1). Table 4-1 is reproduced in the following pages of this HRS documentation record for the convenience of the reader.

## DRINKING WATER THREAT

| Factor Categories and Factors | | Maximum Value | Value Assigned |
|---|---|---|---|
| | Likelihood of Release | | |
| 1. | Observed Release | 550 | 550 |
| 2. | Potential to Release by Overland Flow: | | |
| | 2a. Containment | 10 | NS |
| | 2b. Runoff | 25 | NS |
| | 2c. Distance to Surface Water | 25 | NS |
| | 2d. Potential to Release by Overland Flow (lines 2a[2b + 2c]) | 500 | NS |
| 3. | Potential to Release by Flood: | | |
| | 3a. Containment (Flood) | 10 | NS |
| | 3b. Flood Frequency | 50 | NS |
| | 3c. Potential to Release Flood (lines 3a x 3b) | 500 | NS |
| 4. | Potential to Release (lines 2d + 3c, subject to a maximum of 500) | 500 | NS |
| 5. | Likelihood of Release (higher of lines 1 and 4) | 550 | 550 |
| | Waste Characteristics | | |
| 6. | Toxicity/Persistence | a | 10,000 |
| 7. | Hazardous Waste Quantity | a | 1,000,000 |
| 8. | Waste Characteristics (Toxicity/Persistence x Hazardous Waste Quantity, then assign a value from Table 2-7) | 100 | 100 |
| | Targets | | |
| 9. | Nearest Intake | 50 | NS |
| 10. | Population | | |
| | 10a. Level I Concentrations | b | NS |
| | 10b. Level II Concentrations | b | NS |
| | 10c. Potential Contamination | b | NS |
| | 10d. Population (lines 10a + 10b + 10c) | b | NS |
| 11. | Resources | 5 | 5 |
| 12. | Targets (lines 9 + 10d +11) | b | 5 |
| | Drinking Water Threat Score | | |
| 13. | Drinking Water Threat Score [(lines 5 x 8 x 12)/82,500 subject to a maximum of 100] | 100 | 3.33 |

## HUMAN FOOD CHAIN THREAT

| Factor Categories and Factors | | Maximum Value | Value Assigned |
|---|---|---|---|
| | Likelihood of Release | | |
| 14. | Likelihood of Release (Same value of line 5) | 550 | 550 |
| | Waste Characteristics | | |
| 15. | Toxicity/Persistence/ Bioaccumulation | a | $5x10^8$ |
| 16. | Hazardous Waste Quantity | a | 1,000,000 |
| 17. | Waste Characteristics (Toxicity/Persistence/Bioaccumulation x Hazardous Waste Quantity, then assign a value from Table 2-7) | 1,000 | 1,000 |
| | Targets | | |
| 18. | Food Chain Individual | 50 | 45 |
| 19. | Population | | |
| | 19a. Level I Concentrations | b | 0 |
| | 19b. Level II Concentrations | b | 0.03 |
| | 19c. Potential Human Food Chain Contamination | b | 0.003 |
| | 19d. Population (lines 19a + 19b + 19c) | b | 0.033 |
| 20. | Targets (lines 18 + 19d) | b | 45.033 |
| | Human Food Chain Threat Score | | |
| 21. | Human Food Chain Threat Score [(lines 14 x 17 x 20)/82,500 subject to a maximum of 100] | 100 | 100 |

**ENVIRONMENTAL THREAT- Not Scored (NS)**

| | Factor Categories and Factors | Maximum Value | Value Assigned |
|---|---|---|---|
| | Likelihood of Release | | |
| 22. | Likelihood of Release (Same value of line 5) | 550 | 550 |
| | Waste Characteristics | | |
| 23. | Ecosystem Toxicity/Persistence Bioaccumulation | a | NS |
| 24. | Hazardous Waste Quantity | a | NS |
| 25. | Waste Characteristics (Ecosystem Tox./Persistence x Bioaccumulation x Hazardous Waste Quantity, then assign a value from Table 2-7) | 1,000 | NS |
| | Targets | | |
| 26. | Sensitive Environments | | |
| | 26a. Level I Concentrations | b | NS |
| | 26b. Level II Concentrations | b | NS |
| 26c. | Potential Contamination | | |
| | 26c. Potential Contamination | b | NS |
| 26d. | Sensitive Environments (lines 26a + 26b + 26c) | b | NS |
| 27. | Targets (value from line 26d) | b | NS |
| | Environmental Threat Score | | |
| 28. | Environmental Threat Score [(lines 22 x 25 x 27)/82,500 subject to a maximum of 60] | 60 | NS |

**SURFACE WATER OVERLAND/FLOOD MIGRATION COMPONENT SCORE FOR A WATERSHED**

| | | | |
|---|---|---|---|
| 29. | Watershed Score [(Lines 13 + 21+ 28), subject to a maximum of 100] | 100 | 100 |

**SURFACE WATER OVERLAND/FLOOD MIGRATION COMPONENT SCORE**

| | | | |
|---|---|---|---|
| 30. | Component Score (Highest score from Line 29 for all watersheds evaluated, subject to a maximum of 100) | 100 | 100 |

# SOURCE DESCRIPTION

## 2.2 Source Characterization

**Source Description: Source 1 – Open Pits**

Mining operations at the Jackpile-Paguate Uranium Mine resulted in approximately 2,656 acres of surface disturbance, of which the open pits accounted for approximately 1,015 acres (Ref. 4, pp. 24, 59). The location of this source is depicted on Figure A-2 and features of the open pit can be found in References 28 and 29.

Mining operations were conducted from 1953 through early 1982 from three open pits, Jackpile, North Paguate, and South Paguate that were between 200 and 300 feet deep. Open pit mining was conducted predominantly with large front-end loaders and haul trucks. The uranium ore was segregated according to grade and stockpiled for shipment to the mill. Overburden and ore-associated waste was placed in the mined-out areas of the pits as backfill (Ref. 4, p. 21; Ref. 5, p. 184; Ref. 28).

The Jackpile, North Paguate, and South Paguate open pits make up approximately 40 percent of the total disturbed acreage at the mine (see Figure A-2 and References 28 and 29). During the later years of mining, some overburden was placed into the mined-out portions of the pits. Approximately 101 million tons of backfill composed principally of ore-associated waste with some overburden have been returned to the pits (Ref. 4, p. 56, 69). The southern portion of the Jackpile Pit and the South Paguate Pit received most of this material. There were no requirements to keep records on the radiological content of the backfill material (Ref. 4, p. 69).

As stated above, the wastes generated at Jackpile-Paguate Uranium Mine were not removed from the facility but used for backfill. There was no impermeable cap placed on top of the backfill other than 3 feet of overburden (material removed during surface mining and stockpiled) and 2 feet of topsoil (Ref. 4, p. 64; Ref. 5, p. 7; Ref. 31, p. 1).

The three pits are being aggregated into one source within this HRS documentation record because they are all the same source type (piles), have the same target (as described in Section 4.1.3.3 of this report), have the same containment (as described below), contain the same hazardous substances (as described in Section 2.4.1) and are located in the same watershed (see Section 4.0). In addition, radiological analytical results from the ESI show elevated concentrations of gross alpha and gross beta (Ref. 35, pp. 3, 30, 33).

**Source Type**

The waste contents were contained within the former open pit uranium mine, which over the 29 years of operation, accumulated piles of contamination (Ref. 4, p. 24; Ref. 5, p. 11). These piles of contamination were not removed from the facility, but used to backfill the open pits. The backfill material consists of protore and waste dumps, and as such, the source type for Source 1 is “Pile” (Ref. 1, Table 2-5; Ref. 5, p. 7).

**Source Location**

The Jackpile Pit is located along the eastern side of the mine starting at the north side and continuing about midway down the facility, the North Paguate Pit is located on the north western side of the facility, and the South Paguate Pit is located on the southwest corner of the facility (Ref. 29, p. 1).

## Source Containment

### Release To Surface Water

Contents of the three open pits are exposed to the elements and can release to the surface water through run off. The perennial surface water, Rios Moquino and Paguate, run though the center of the mine and are exposed to the source through run off and there is no maintained engineered cover, liner, and a run-on control system and runoff management system (Ref. 31, p. 1). The open pits remained as closed basins and were covered with just 3 feet of overburden and 2 feet of topsoil, and although required as part of the ROD, no berms were placed to control surface runoff (Ref. 3, p. 1; Ref. 5, p. 7; Ref. 7, p. 10).

A containment value of 10 was selected for Source 1 because there is no maintained engineered cover, liner, and a run-on control system and runoff management system (Ref. 1, Section 4.1.2.1.2.1.1).

Containment Value: 10

### 2.4.1 Hazardous Substances

On 03 and 04 March 2010, as part of the Site Inspection (SI) of the Jackpile-Paguate Uranium Mine facility, the EPA Region 6 Superfund Technical Assessment Response Team (START-3) contractor, collected the following source samples at the Jackpile-Paguate Mine: one solid waste sample, JM-SS-01, collected from the South Paguate Pit: one solid waste sample (JM-SED-02) and one liquid waste sample (JM-SW-02), collected from the North Paguate Pit; and one solid waste sample, JM-SS-05 collected from the Jackpile Pit (Ref. 8, Figure 3-1; Ref. 19, pp. 2, 8, 20, 21, 35; Ref. 29; Figure A-2). The solid waste samples are considered appropriate source samples since the presence of contamination in the waste rock used to backfill the open pits. The liquid waste sample (collected from sample location JM-02) is also considered an appropriate source sample because this former open pit continues to fill with water; this sample further demonstrates the presence of contamination associated with the open pits.

On 19 through 21 April 2011, as part of the ESI of the Jackpile-Paguate Uranium Mine property, the START-3 contractor collected subsurface source samples from the Jackpile, (JPOP41S), North Paguate (NPOP20E), and South Paguate (SPOP35) open pits at the Jackpile-Paguate Mine (Ref. 35, pp. 23, 26, 78-81, 119).

The solid and liquid waste samples were collected according to the EPA approved Quality Assurance Sampling Plans (QASPs) (Ref. 30, p. 18; Ref. 35, pp. 111-113). The solid waste samples were collected with disposable plastic scoops, and then transferred to an 8-ounce sample container (Ref. 8, pp. 15, 17; Ref. 35, pp. 222). The surface liquid waste sample was collected by submerging the sample container into the liquid, facing the mouth of the container upstream while sampling personnel stood downstream (Ref. 8, p. 113; Ref. 35 p. 216). The subsurface source samples were collected using low flow sampling techniques and a pneumatic pump (Ref. 35, pp. 78-81, 113).

A total of 6 source samples were collected from former open pit locations within the mine area including two solid waste samples, one liquid waste sample, and three subsurface water samples. The samples collected in March 2010 were shipped via Federal Express to ALS Laboratory Group located in Fort Collins, Colorado (Ref. 8, p. 16; Ref. 19, pp. 11, 13). The samples were analyzed for total metals by EPA Methods SW-846 3005A(liquid) 3050B (solid) and 6010B, total cyanide by EPA Methods SW-846 9010 and 9014, mercury by EPA Methods SW-846 7470A/7471A and SOP812 Rev. 14, and isotopic uranium by SOP778R13 and SOP714R11 (Ref. 20, pp. 13, 51, 542, 720, 758, 1170). The April 2011 samples were analyzed for: isotopic uranium (isotopes 234, 235, and 238) by method Eichrom ACW-03-15 and ACW-10; total metals by EPA method 200.7 for water and 6010B for solids; selenium by EPA method 6020; mercury by EPA method 7470A/7471A; Radium$^{226}$ by EPA method 903; and Radium$^{228}$ by EPA method 904. In addition, all water samples were also analyzed for: alkalinity by method SM2310-B; bicarbonate by method SM-17 2320; carbonate by method SM 4500-CO2D; Total Dissolved Solids by method SM 2540-C; and anions by EPA method 300 (Ref. 35, pp. 336-414, 437-446, 756-780; Ref. 36, pp. 4-5).Once final analytical results were received, the data underwent a third-party data review and validation performed by a START-3 chemist or professional health physicist (for radiological data) not associated with the sampling conducted at the facility (Ref. 8; Ref. 25; Ref. 36, p. 5).

Analytical evidence of the contamination in open pit source samples associated with the mine operations at the Jackpile-Paguate Uranium Mine facility are summarized as follows:

**Source 1 Radioactive Results**

| Hazardous Substance | Evidence | | | | References |
|---|---|---|---|---|---|
| | Station Location No. | Concentration | Reporting Limit[2]/ MDC/LOD | Units[1] | |
| **EPA Site Inspection Activities – March 2010[3]** | | | | | |
| Uranium$^{234}$ | JM-SS-01 | 0.00173 | 0.0 | ug/g | Ref. 19, p. 23; Ref. 20, pp. 714, 1218; Ref. 26, pp. 1 to 3 |
| Uranium$^{235}$ | | 0.343 | 0.015 | ug/g | Ref. 19, p. 23; Ref. 20, pp. 714, 1218; Ref. 26, pp. 1 to 3 |
| Uranium$^{238}$ | | 40.8 | 0.1 | ug/g | Ref. 19, p. 23; Ref. 20, pp. 714, 1218; Ref. 26, pp. 1 to 3 |
| Uranium$^{234}$ | JM-SED-02 | 0.0224 | 0.0 | ug/g | Ref. 19, p. 35; Ref. 20, pp. 712, 1209; Ref. 26 pp. 1 to 3 |
| Uranium$^{235}$ | | 2.62 | 0.03 | ug/g | Ref. 19, p. 35; Ref. 20, pp. 712, 1209; Ref. 26 pp. 1 to 3 |
| Uranium$^{238}$ | | 367 | 0.0 | ug/g | Ref. 19, p. 35; Ref. 20, pp. 712, 1209; Ref. 26 pp. 1 to 3 |
| Uranium$^{234}$ | JM-SW-02 | 0.538 | 0.0 | ug/g | Ref. 19, p. 35; Ref. 20, pp. 712, 1211; Ref. 26 pp. 1 to 3 |
| Uranium$^{235}$ | | 61 | 1.0 | ug/g | Ref. 19, p. 35; Ref. 20, pp. 712, 1211; Ref. 26 pp. 1 to 3 |
| Uranium$^{238}$ | | 8,500 | 0.0 | ug/g | Ref. 19, p. 35; Ref. 20, pp. 712, 1211; Ref. 26 pp. 1 to 3 |
| Uranium$^{234}$ | JM-SS-05 | 0.0144 | 0.0 | ug/g | Ref. 19, pp. 20 to 21; Ref. 20, pp. 711, 1204; Ref. 26, pp. 1 to 3 |

| Hazardous Substance | Evidence | | | | References |
|---|---|---|---|---|---|
| | Station Location No. | Concentration | Reporting Limit[2]/ MDC/LOD | Units[1] | |
| Uranium$^{235}$ | | 2.06 | 0.13 | ug/g | Ref. 19, pp. 20 to 21; Ref. 20, pp. 711, 1204; Ref. 26, pp. 1 to 3 |
| Uranium$^{238}$ | JM-SS-05 | 271 | 0.0 | ug/g | Ref. 19, pp. 20 to 21; Ref. 20, pp. 711, 1204; Ref. 26, pp. 1 to 3 |
| **EPA Expanded Site Inspection Activities – April 2011[3]** | | | | | |
| Thorium$^{230}$ | NPOP20E | 1.85 | 0.198 | pCi/l | Ref. 35, pp. 79, 740, 768, 1587 |
| Uranium$^{234}$ | | 36,500 | 2.20 | pCi/l | Ref. 35, pp. 79, 740, 768, 1587 |
| Uranium$^{235}$ | | 40,400 | 2.55 | pCi/l | Ref. 35, pp. 79, 740, 768, 1587 |
| Uranium$^{238}$ | | 64,300 | 2.20 | pCi/l | Ref. 35, pp. 79, 740, 768, 1587 |
| Radium$^{226}$ | | 33.2 | 0.74 | pCi/l | Ref. 35, pp. 79, 379, 422, 1587 |
| Radium$^{228}$ | | 13.9 | 0.92 | pCi/l | Ref. 35, pp. 79, 379, 422, 1587 |
| Thorium$^{228}$ | SPOP35 | 0.075 | 0.041 | pCi/l | Ref. 35, pp. 78, 79, 748, 779, 1587 |
| Uranium$^{234}$ | | 7840 | 0.208 | pCi/l | Ref. 35, pp. 78, 79, 748,779, 1587 |
| Uranium$^{235}$ | | 6450 | 0.241 | pCi/l | Ref. 35, pp. 78, 79, 748,779, 1587 |
| Uranium$^{238}$ | | 9950 | 0.207 | pCi/l | Ref. 35, pp. 78, 79, 748,779, 1587 |
| Radium$^{226}$ | | 17.3 | 0.74 | pCi/l | Ref. 35, pp. 78, 79, 390, 430, 1587 |
| Radium$^{228}$ | | 17.3 | 0.92 | pCi/l | Ref. 35, pp. 78, 79, 390, 430, 1587 |
| Thorium$^{228}$ | JPOP41S | 0.247 | 0.164 | pCi/l | Ref. 35, pp. 81, 736, 759, 1587 |
| Thorium$^{230}$ | | 1.49 | 0.187 | pCi/l | Ref. 35, pp. 81, 736,759, 1587 |
| Uranium$^{234}$ | | 63,300 | 9.05 | pCi/l | Ref. 35, pp. 81, 736,759, 1587 |
| Uranium$^{235}$ | | 72,100 | 1.57 | pCi/l | Ref. 35, pp. 81, 736, 759, 1587 |
| Uranium$^{238}$ | | 114,000 | 1.35 | pCi/l | Ref. 35, pp. 81, 736, 759, 1587 |
| Radium$^{226}$ | | 208 | 0.74 | pCi/l | Ref. 35, pp. 81, 373, 417, 1587 |
| Radium$^{228}$ | | 38.3 | 0.92 | pCi/l | Ref. 35, pp. 81, 373, 417, 1587 |

Notes:

[1] ug/g – microgram per gram = milligram per kilogram (mg/kg)
pCi/l – picocurie per liter

[2] The Reporting Limit is defined as the Minimum Detectable Concentration (MDC) for uranium and thorium by Alpha Spectroscopy is the net concentration that has a specified chance of being detected (Ref. 39, p. 3). Limit of Detection (LOD) is equal to the Laboratory Detection Limit for radium (Ref. 35, p. 337)

[3] Radiological data were validated by a START-3 Certified Health Physicist with 30 years of radiation characterization experience. Data for target analytes meet the definitive data quality objective (Ref. 26, p. 49; Ref. 35, p. 1534).

## Source 1 Non-Radioactive Results

| Hazardous Substance | Evidence | | | | References |
|---|---|---|---|---|---|
| | Station Location No. | Concentration | Reporting Limit[2] | Units[1] | |
| **EPA Site Inspection Activities – March 2010[3]** | | | | | |
| Vanadium | JM-SS-01 | 30 | 1 | mg/kg | Ref. 19, p. 23; Ref. 20, pp. 714, 791; Ref. 25, pp. 45 to 49 |
| Chromium | JM-SED-02 | 5.8 | 1.7 | mg/kg | Ref. 19, p. 35; Ref. 20, pp. 712, 785; Ref. 25, pp. 45 to 49 |
| Manganese | | 270 | 1.7 | mg/kg | Ref. 19, p. 35; Ref. 20, pp. 712, 785; Ref. 25, pp. 45 to 49 |
| Vanadium | | 15 | 1.7 | mg/kg | Ref. 19, p. 35; Ref. 20, pp. 712, 785; Ref. 25, pp. 45 to 49 |
| Zinc | | 36 | 3.4 | mg/kg | Ref. 19, p. 35; Ref. 20, pp. 712, 785; Ref. 25, pp. 45 to 49 |
| Cobalt | JM-SW-02 | 0.023 | 0.01 | mg/l | Ref. 19, p. 35; Ref. 20, pp. 712, 776; Ref. 25, pp. 45 to 49 |
| Manganese | | 1.3 | 0.01 | mg/l | Ref. 19, p. 35; Ref. 20, pp. 712, 776; Ref. 25, pp. 45 to 49 |
| Zinc | | 0.026 | 0.02 | mg/l | Ref. 19, p. 35; Ref. 20, pp. 712, 776; Ref. 25, pp. 45 to 49 |
| Vanadium | JM-SS-05 | 90 | 1 | mg/kg | Ref. 19, pp. 20 to 21; Ref. 20, pp. 711, 783; Ref. 25, pp. 45 to 49 |
| **EPA Expanded Site Inspection Activities – April 2011[3]** | | | | | |
| Chromium | NPOP20E | 0.0604 | 0.00109 | mg/l | Ref. 35, pp. 79, 350, 422, 1527, 1534, 1547 |
| Cobalt | | 0.0692 | 0.00051 | mg/l | Ref. 35, pp. 79, 350, 422, 1527, 1534, 1547 |
| Manganese | | 4.633 | 0.00043 | mg/l | Ref. 35, pp. 79, 350, 422, 1527, 1534, 1547 |
| Chromium | SPOP35 | 0.0057 | 0.00109 | mg/l | Ref. 35, pp. 78, 79, 371, 430, 1527, 1534, 1568 |
| Manganese | | 0.186 | 0.00043 | mg/l | Ref. 35, pp. 78, 79, 371, 430, 1527, 1534, 1568 |
| Chromium | JPOP41S | 0.365 | 0.00109 | mg/l | Ref. 35, pp. 81, 338, 417,1527, 1534, 1535 |
| Cobalt | | 0.0788 | 0.00051 | mg/l | Ref. 35, pp. 81, 338, 417,1527, 1534, 1535 |
| Manganese | | 2.84 | 0.00043 | mg/l | Ref. 35, pp. 81, 338, 417,1527, 1534, 1535 |

Notes:

[1] mg/kg –milligram per kilogram
mg/l – milligram per liter

[2] The Reporting Limit is defined as the Limit of Detection (LOD) for the April 2011 data provided by Summit Analytical Laboratories. The LOD is equal to the Laboratory Detection Limit which is adjusted for dilution factors (Ref. 35, p. 337). The definition of the Reporting Limit used by ALS Laboratory Group was not provided in the laboratory package (Ref. 20, pp. 758 to 762).

[3] Chemical laboratory data collected during EPA SI and ESI activities were validated by a START-3 chemist in accordance with *EPA*

*USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review* (July 2002), and the Regional Protocol for Holding Times, Blanks, and VOA Preservation (April 13, 1989). Data for target analytes meet the definitive data quality objective (Ref. 25, pp. 5, 36, 49, 74).

### 2.4.2 Hazardous Waste Quantity

#### 2.4.2.1 Source Hazardous Waste Quantity

##### 2.4.2.1.1 Tier A: Hazardous Constituent Quantity - Not Evaluated (NE)

Information on the exact measure (in pounds) of individual hazardous substances in this source is not available to evaluate Tier A, hazardous constituent quantity. The number of samples collected is not statistically representative of the range of concentrations throughout the source. Therefore, it is not possible to adequately determine a hazardous constituent quantity for Source 1 with reasonable confidence (Ref. 1, Section 2.4.2.1.1). Scoring proceeds to the evaluation of Tier B, hazardous wastestream quantity (Ref. 1, Section 2.4.2.1.2).

##### 2.4.2.1.2 Tier B: Hazardous Wastestream Quantity - Not Evaluated (NE)

The information on the total mass of all hazardous wastestreams and CERCLA pollutants and contaminants for Source 1 is not sufficient to evaluate Tier B, hazardous wastestream quantity. There is insufficient information that documents wastestream disposal over the facilities operational life; therefore, it is not possible to adequately determine a complete hazardous wastestream quantity for Source 1 (Ref. 1, Section 2.4.2.1.2). Scoring proceeds to the evaluation of Tier C, volume (Ref. 1, Section 2.4.2.1.3).

##### 2.4.2.1.3 Tier C: Volume – Not Evaluated (NE)

The depth of each pit could not be accurately determined based on the information available. Therefore, information is not sufficient to evaluate Tier C and it is not possible to adequately determine a volume for Source 1 (Ref. 1, Section 2.4.2.1.2). Scoring proceeds to the evaluation of Tier D, area (Ref. 1, Section 2.4.2.1.3).

##### 2.4.2.1.4 Tier D: Area

Although the area of Source 1, open pits, was stated to be approximately 1,015 acres (or 44,213,400 square feet [$ft^2$]) according to references reviewed, this area calculation could not be reproduced. Therefore, an approximate calculation was performed using GIS software. The GIS software calculated the area of the polygons drawn over each of the pit's basal footprints, outlined by contours visible in current aerials and within a topographic map included as part of the ROD Compliance Assessment (Ref. 4, p. 11; Ref. 29, p. 1; Ref. 33, pp. 2, 3). This calculation only includes the flat area and does not include the large slopes which are part of each pit. The GIS software calculated the area of Jackpile Pit to be 7,310,080 $ft^2$, the area of North Paguate Pit to be 2,570,040 $ft^2$ and the area of South Paguate Pit to be 2,700,720 $ft^2$. The total area of all three pits is 12,580,840 $ft^2$ (Ref. 33, pp. 1-3). The Tier D equation for assigning a value for area of a Pile is A/13 (Ref. 1, Table 2-5).

Area of Source 1 ($ft^2$): 12,580,840

Area Assigned Value = 12,580,840 $ft^2$ /13

Area Assigned Value = 967,756.923

### 2.4.2.1.5 Source Hazardous Waste Quantity Value

Per the HRS, the highest of the values assigned to the source for hazardous constituent quantity (Tier A), hazardous wastestream quantity (Tier B), Volume (Tier C), and Area (Tier D) should be assigned as the source hazardous waste quantity value (Ref. 1, Section 2.4.2.1.5). This hazardous waste value is based on the non-radioactive hazardous substances only and does not include the radioactive substances. There is insufficient information to accurately score the radioactive hazardous waste quantity value and not scoring radioactive hazardous waste quantity does not affect the listing decision (Ref. 1, Section 7.2.5.3, Table 2-6).

| Tier Evaluated | Source 1 Values |
|---|---|
| A | Not Evaluated |
| B | Not Evaluated |
| C | 0 |
| D | 967,756.923 |

Source 1 Hazardous Waste Quantity Value: 967,756.923

## Source Description: Source 2 – Waste Dump V

Mining operations at the Jackpile-Paguate Uranium Mine resulted in approximately 2,656 acres of surface disturbance (Ref. 4, pp. 56, 59). The only waste dump sampled and evaluated for this source is identified as Waste Dump V (Ref. 29). The mine contained 32 waste dumps that account for approximately 48 percent of the disturbed area (Ref. 4, p. 61). The location of Waste Dump V is depicted on Figure A-2 and the location of all the waste dumps can be found in References 28 and 29.

The tops of 17 waste dumps were reclaimed between 1976 and 1979. The tops were contoured to a slight slope, water spreading berms were constructed, large boulders were pushed into piles, 18 to 24 inches of soil were spread, and the dumps were seeded (Ref. 4, p. 69). In later years, as part of the mine reclamation project, the waste dumps were re-sloped, with those containing Jackpile Sandstone at the surface covered with 3 feet of overburden and 16 inches of topsoil. Waste dumps that did not contain Jackpile Sandstone were covered with 18 inches of topsoil (Ref. 5, pp. 7, 8).

As stated above, the wastes generated at Jackpile-Paguate Uranium Mine were not removed from the property but left in place and covered with overburden. There was no impermeable cap placed on top of the backfill other than overburden (material removed during surface mining and stockpiled) and topsoil (Ref. 4, p. 64; Ref. 5, p. 8). In addition, radiological analytical results from the ESI show elevated concentrations of gross alpha and gross beta (Ref. 35, pp. 3, 30, 33).

## Source Type

Waste rock accumulated in piles of contamination and was placed in waste dumps (Ref. 4, pp. 21, 61). These piles of contamination were not removed from the property, but were left in place and sloped and covered with overburden. As such, the source type for Source 2 is “Pile” (Ref. 1, Table 2-5; Ref. 5, pp. 7, 8).

## Source Location

Waste Dump V is located just to the east and abutting Rio Moquino, just north of where Rio Moquino and Rio Paguate converge (Ref. 29, p. 1; Figure A-2).

## Source Containment

### Release To Surface Water

Contents of Waste Dump V are exposed to the elements and can release to the surface water through direct contact and run off. Portions of the perennial surface water body, Rio Moquino are in direct contact with the source. According to Laguna officials, the river banks were not reclaimed and source materials are present there (Ref. 19, p. 5). Source sample JM-SS-03 was collected during draught conditions and therefore was not in direct contact with the surface water. However, after rain events, the Rio Moquino would contain water such that sample location JM-SS-03 would be in direct contact with the surface water (Ref. 19, pp. 4, 6, 7). There is no maintained engineered cover, liner, and a run-on control system and runoff management system (Ref. 31, p. 1). There are several dumps with chronic erosion problems and berming performed as part of the reclamation did not perform as expected (Ref. 3, p. 1; Ref. 5, p. 31; Ref. 7, p. 10). Waste Dump V slopes steeply into Rio Moquino

(Ref. 29, p. 1).

A containment value of 10 was selected for Source 2 based on the surface water being in direct contact with the source and there is no maintained engineered cover, liner, and a run-on control system and runoff management system (Ref. 1, Section 4.1.2.1.2.1.1; Ref. 31, p.1).

Containment Value: 10

### 2.4.1 Hazardous Substances

On 03 March 2010, as part of the SI of the Jackpile-Paguate Uranium Mine property, the EPA Region 6 START-3 contractor, collected one solid waste sample JM-SS-03 from this source at the Jackpile-Paguate Mine. This sample is considered an appropriate source sample as it was located where Waste Dump V was identified on reclamation figures and by Marvin Sarracino, Pueblo of Laguna Reclamation Project Technician (Ref. 19, pp. 2, 8, 21; Ref. 29; Figure A-2).

The solid waste sample was collected according to the approved QASP (Ref. 30, p. 18). The solid waste sample was collected with disposable plastic scoops, and then transferred to an 8-ounce sample container (Ref. 8, pp. 15, 17). The solid waste sample was collected from near surface (Ref. 8, p. 107).

The sample was shipped via Federal Express to ALS Laboratory Group located in Fort Collins, Colorado (Ref. 8, p. 16; Ref. 19, pp. 11, 23). The sample was analyzed for total metals by EPA Methods SW-846 3005A(liquid) 3050B (solid) and 6010B, total cyanide by EPA Methods SW-846 9010 and 9014, mercury by EPA Methods SW-846 7470A/7471A and SOP812 Rev. 14, and isotopic uranium by SOP778R13 and SOP714R11 (Ref. 20, pp. 13, 51, 542, 720, 758, 1170). Once final analytical results were received, the data underwent a third-party data review and validation performed by a START-3 chemist not associated with the sampling conducted at the property (Ref. 8; Ref. 25).

Analytical evidence of the contamination in Source 2 is summarized as follows:

**Source 2 Radioactive Results**

| Hazardous Substance | Evidence | | | References |
|---|---|---|---|---|
| | Station Location No. | Concentration (ug/g)[1] | Reporting Limit[2] | |
| **EPA Site Inspection Activities – March 2010[3]** | | | | |
| Uranium$^{234}$ | JM-SS-03 | 224 | 0.0 | Ref. 19, p. 21; Ref. 20, pp. 712, 1210; Ref. 26, pp. 1 to 3 |
| Uranium$^{235}$ | | 2.62 | 0.03 | Ref. 19, p. 21; Ref. 20, pp. 712, 1210; Ref. 26, pp. 1 to 3 |
| Uranium$^{238}$ | | 367 | 0.0 | Ref. 19, p. 21; Ref. 20, pp. 712, 1210; Ref. 26, pp. 1 to 3 |

Notes:
[1] ug/g – microgram per gram
[2] The Reporting Limit is defined as the MDC for uranium by Alpha Spectroscopy and is the net concentration that has a specified chance of being detected (Ref. 39, p. 3).
[3] Uranium data were validated by a START-3 Certified Health Physicist with 30 years of radiation characterization experience. Data for target analytes meet the definitive data quality objective (Ref. 26).

**Source 2 Non-Radioactive Results**

| Hazardous Substance | Evidence | | | References |
|---|---|---|---|---|
| | Station Location No. | Concentration (mg/kg)[1] | Reporting Limit[2] | |
| **EPA Site Inspection Activities – March 2010[3]** | | | | |
| Manganese | JM-SS-03 | 84 | 1 | Ref. 19, p. 21; Ref. 20, pp. 712, 786; Ref. 25, pp. 45 to 49 |
| Vanadium | JM-SS-03 | 20 | 1 | Ref. 19, p. 21; Ref. 20, pp. 712, 786; Ref. 25, pp. 45 to 49 |

Notes:
mg/kg - milligram per kilogram (mg/kg) = parts per million (ppm)

[2] The Reporting Limit is defined as the Minimum Detectable Concentration for uranium by Alpha Spectroscopy and as the Sample Quantitation Limit adjusted for sample aliquot, sample volume, and dilutions for the metals analysis (Ref. 32).

[3] Chemical laboratory data collected during EPA SI and ESI activities were validated by a START-3 chemist in accordance with *EPA USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review* (July 2002), and the Regional Protocol for Holding Times, Blanks, and VOA Preservation (April 13, 1989). Data for target analytes meet the definitive data quality objective (Ref. 25, pp. 5, 36, 49, 74).

## 2.4.2 Hazardous Waste Quantity

### 2.4.2.1 Source Hazardous Waste Quantity

#### 2.4.2.1.1 Tier A: Hazardous Constituent Quantity - Not Evaluated (NE)

Information on the exact measure (in pounds) of individual hazardous substances in this source is not available to evaluate Tier A, hazardous constituent quantity. The number of samples collected is not statistically representative of the range of concentrations throughout the source. Therefore, it is not possible to adequately determine a hazardous constituent quantity for Source 2 with reasonable confidence (Ref. 1, Section 2.4.2.1.1). Scoring proceeds to the evaluation of Tier B, hazardous wastestream quantity (Ref. 1, Section 2.4.2.1.2).

#### 2.4.2.1.2 Tier B: Hazardous Wastestream Quantity - Not Evaluated (NE)

The information on the total mass of all hazardous wastestreams and CERCLA pollutants and contaminants for Source 2 is not sufficient to evaluate Tier B, hazardous wastestream quantity. There is insufficient information that documents wastestream disposal over the facilities operational life; therefore, it is not possible to adequately determine a complete hazardous wastestream quantity for Source 2 (Ref. 1, Section 2.4.2.1.2). Scoring proceeds to the evaluation of Tier C, volume (Ref. 1, Section 2.4.2.1.3).

#### 2.4.2.1.3 Tier C: Volume – Not Evaluated (NE)

The depth of Waste Dump V could not be accurately determined based on the information available. Therefore, information is not sufficient to evaluate Tier C and it is not possible to adequately determine a volume for Source 2 (Ref. 1, Section 2.4.2.1.2). Scoring proceeds to the evaluation of Tier D, area (Ref. 1, Section 2.4.2.1.3).

#### 2.4.2.1.4 Tier D: Area

The area of Source 2, Waste Dump V, was determined using GIS software. The GIS software calculated the area of the basal footprint polygon of Waste Dump V, outlined by contours visible in current aerials and within a topographic map included as part of the ROD Compliance Assessment (Ref. 4, p. 11; Ref. 29, p. 1; Ref. 33, pp. 2, 3). The GIS software calculated the area of Waste Dump V to be 566,280 $ft^2$ (Ref. 33, pp. 1-3). The Tier D equation for assigning a value for area of a Pile is A/13 (Ref. 1, Table 2-5).

Area of Source 2 ($ft^2$): 566,280

Area Assigned Value = 566,280 $ft^2$ /13

Area Assigned Value = 43,560

### 2.4.2.1.5 Source Hazardous Waste Quantity Value

Per the HRS, the highest of the values assigned to the source for hazardous constituent quantity (Tier A), hazardous wastestream quantity (Tier B), Volume (Tier C), and Area (Tier D) should be assigned as the source hazardous waste quantity value (Ref. 1, Section 2.4.2.1.5). This hazardous waste value is based on the non-radioactive hazardous substances only and does not include the radioactive substances. There is insufficient information to score the radioactive hazardous waste quantity value and not scoring radioactive hazardous waste quantity does not affect the listing decision (Ref. 1, Section 7.2.5.3, Table 2-6).

| Tier Evaluated | Source 2 Values |
|---|---|
| A | Not Evaluated |
| B | Not Evaluated |
| C | 0 |
| D | 43,560 |

Source 2 Hazardous Waste Quantity Value: 43,560

## Other Possible Sources

Other possible sources associated with the Jackpile-Paguate Uranium Mine site include 31 waste dumps and 23 protore stockpiles. Due to the large area of the Jackpile mine, individual samples could not be collected from these possible source areas. Therefore, these other possible sources were not evaluated separately or used in the scoring of the site. However, the hazardous substances associated with these possible sources are expected to be the same as the scored sources as they resulted from the same mining activities.

Mining operations at the Jackpile-Paguate Uranium Mine resulted in 2,656 acres of surface disturbance (Ref. 4, pp. 56, 59). The mine contained 32 waste dumps that account for approximately 48 percent of the disturbed area (Ref. 4, p. 61).

The tops of 17 waste dumps were reclaimed between 1976 and 1979. The tops were contoured to a slight slope, water spreading berms were constructed, large boulders were pushed into piles, 18 to 24 inches of soil were spread, and the dumps were seeded (Ref. 4, p. 69). In later years, as part of the mine reclamation project, the waste dumps were re-sloped, with those containing Jackpile Sandstone at the surface covered with 3 feet of overburden and 16 inches of topsoil. Waste dumps that did not contain Jackpile Sandstone were covered with 18 inches of topsoil (Ref. 5, pp. 7, 8).

During mining operations, the uranium ore was segregated according to grade and stockpiled for shipment to the mill. Located outside and inside of the open pits were 23 protore stockpiles. The protore that was located outside the pits covered approximately 103 acres and contained approximately 7.2 million cubic yards of material. Those stockpiles located inside the pits contained about 3.1 million cubic yards of material but do not constitute additional acreage of disturbed ground (Ref. 4, p. 61; Ref. 28, pp. 6, 22, 37).

Protore is material that was stockpiled throughout the mining operation because it contains elevated but sub-economic uranium concentrations (Ref. 4, p. 73). Approximately 21 million tons of protore, containing 0.02 to 0.059 percent uranium exist at the mine. This material was located on the surface in 23 stockpiles dispersed throughout the mine (Ref. 4, p. 74). Between 1989 and 1993, these protore stockpiles were moved into the pits (North Paguate Pit , South Paguate Pit, and Jackpile Pit) and used as backfill (Ref. 5, pp. 31, 32).

As stated above, the wastes and protore generated at Jackpile-Paguate Uranium Mine were not removed from the property but left in place and covered. There was no impermeable cap placed on top of the backfill other than overburden (material removed during surface mining and stockpiled), shale, and topsoil (Ref. 4, p. 64; Ref. 5, pp. 8, 31, 32).

## Other Possible Sources Summary

| Possible Source | Rationale | Containment Features | Reference |
|---|---|---|---|
| Waste Dumps | Mining operations at the Jackpile-Paguate mine resulted in 2,656 acres of surface disturbance. Waste rock accumulated in piles of contamination and was placed in a total of 32 waste dumps. One waste dump was evaluated as a source and the remaining 31 waste dumps are considered other possible sources. The dumps were not removed from the property but were left in place and covered with overburden. Contents of the waste dumps are exposed to the elements and can release hazardous substances to surface water through direct contact and run off. Further, portions of the Rio Moquino are in direct contact with some of the waste dumps.<br><br>While specific sampling data does not exist for the 31 waste dumps, hazardous substances associated with these possible sources should be the same hazardous substances associated with Sources 1 and 2 since they resulted from the same mining activities. | There is no maintained engineered cover, liner, or run-on control system or run-off management system. | Ref, 4, pp. 21, 56, 59, 61, 64; Ref. 5, p. 8; Ref. 31, p. 1 |
| Protore Stockpiles | During mining operations, the uranium ore was segregated according to grade and stockpiled for shipment to the mill. Located outside and inside of the open pits were 23 protore stockpiles. The protore stockpiles located outside the open pits covered approximately 103 acres and contained approximately 7.2 million cubic yards of material. The stockpiles located inside the pits contained about 3.1 million cubic yards of material but do not constitute additional acreage of disturbed ground.<br>Protore is material that was stockpiled throughout the mining operation because it contained elevated but sub-economic uranium concentrations. Approximately 21 million tons of protore, containing 0.02 to 0.059 percent uranium exist at the mine site. This material is located on the surface in 23 stockpiles dispersed throughout the mine. The protore stockpiles were not removed from the property but used for backfill material in the pit areas. There was no impermeable cap placed on top of the backfill other than a 1 foot cover of shale and 18 inches of top soil.<br>While specific sampling data does not exist for the 23 protore stockpiles, hazardous substances associated with these possible sources should be the same as those hazardous substances associated with Sources 1 and 2 since they resulted from the same mining activities. | There is no maintained engineered cover, liner, or run-on control system or run-off management system. The only cover consists of 1 foot of shale and 18 inches of topsoil. Materials in the protore stockpiles can release hazardous substances to surface water through direct contact and run off. | Ref. 4, pp. 61, 64, 73, 74; Ref. 5, pp. 31, 32; Ref. 28, pp. 6, 22, 37 |

## SITE SUMMARY OF SOURCE DESCRIPTION

| Source No. | Source Hazardous Waste Quantity Value | Containment | | | |
|---|---|---|---|---|---|
| | | Ground Water | Surface Water | Gas | Air Particulate |
| 1 | 967,756.923 | NE | 10 | NE | NE |
| 2 | 43,560 | NE | 10 | NE | NE |
| TOTAL | 1,011,316.923 | | | | |

NE = Not Evaluated

## 3.0 GROUND WATER MIGRATION PATHWAY SCORE - NOT SCORED

The ground water migration pathway will not be scored because it is not expected to contribute significantly to the site score nor affect the listing decision. The site score exceeds 28.50 and qualifies for listing based only on the evaluation of the surface water pathway.

Although there is historical evidence of contamination through sampling of 11 monitoring wells within the Jackpile-Paguate Uranium Mine, there is a lack of documented ground water targets. The mine floor is generally above the water table and there are no potable wells located downgradient (south) of the property (Ref. 18, p. 11). Annual ground water monitoring was conducted from 1995 through 2007. Analytical results from the post-reclamation ground water sampling showed contamination within the on-site monitoring wells of total uranium concentrations from 0.001 mg/L to 624.51 mg/L. Monitoring Wells MW-1 through MW-7 contained total uranium concentrations that exceeded the EPA MCLs 0.03 mg/L for total uranium at one time or another during this sampling period (Ref. 5, pp. 189, 205, 209; Ref. 21, pp. 1-12).

As part of the April 2011 ESI, ground water samples and hydrologic data were collected from 12 wells at the facility in an effort to further determine whether ground water is a pathway for the migration of contaminants from the property (Ref. 36, p. 4). While this pathway will not be scored for this property, some general information about the aquifers at the property is presented in this section to provide context of the interaction between ground water and surface water.

Regional ground water occurs in both unconsolidated sediments and bedrock. Unconsolidated sediments include Quaternary fluvial, colluvial, and alluvial deposits associated with the Rio Paguate and Rio Moquino systems (Ref. 35, p. 2751). The two principal aquifers in the area are the alluvium and Jackpile sandstone (Ref. 35, p. 2822).

Ground water also occurs in coarse- and medium-grained sedimentary units, including Jurassic sands of the Morrison Formation. Ground water is also present in the capping Quaternary basalts, where it permeates through vesicles and joint fractures; seeps from these basalts likely provide the headwaters for the perennial surface waters of Rios Paguate and Moquino (Ref. 35, p. 2751).

The Alluvial Aquifer is comprised of coarse- to fine-grained clastic sediments – primarily sands - transported and deposited by the fluvial system. The alluvium is described as up to 80 to 100 feet thick in some parts of the basin, thickening with distance from the source areas of the surface water system. The water-bearing units are approximately 20 feet thick throughout the study area, and the hydraulic conductivity (K) for this aquifer is calculated at 23 feet per day (Ref. 35, p. 2751).

Ground water chemistry in the Alluvial Aquifer is dominated by calcium-magnesium cations and sulfate-bicarbonate anions, and is classified as calcium-sufate-bicarbonate water by Hydro-Search (Ref. 35, p. 2870). Total dissolved solids (TDS) concentrations are historically quite variable, ranging from 671 to 3,200 mg/L, but generally increase with the flow direction across the mine (Ref. 35, pp. 2751, 2870).

The Jackpile Sandstone Aquifer is described as an aquifer by the USGS (Ref. 35, p. 2802, 2822). The petrology of the Jackpile Sandstone is described as a light-colored, friable fine to medium sandstone of

variable thickness (up to several hundred feet thick in the study area). The Jackpile Aquifer is stratigraphically confined at the base by thick, black shale of the Morrison Formation (Jurassic), and above by thick shale mapped as part of the Dakota Sandstone (Cretaceous). The shale sandwich confines the Jackpile Sandstone Aquifer in all areas, except where the shale units are not intact (such as areas where the Dakota has been removed by natural erosion or mining activities) (Ref. 35, p. 2751).

The water chemistry of the Jackpile Aquifer is dominated by sodium cations and sulfate to bicarbonate anions, and is classified as a sodium-sulfate-bicarbonate water by Hydro-Search (Ref. 35, p. 2870). TDS for the Jackpile Aquifer ranges from 666 to 1,577 mg/l (Ref. 35, pp. 2870, 2751).

The surface of the Jackpile Aquifer slopes generally to the southeast, although it appears to be affected by activities near the mine, where it becomes unconfined (Ref. 35, p. 2752). The USGS (1885) calculated a hydraulic conductivity for the Jackpile Aquifer of 0.3 feet per day, which is two orders of magnitude lower than the Alluvial Aquifer (Ref. 35, p. 2838). This has important consequences, as when the Jackpile and Alluvial aquifers are in direct contact with each other, the Alluvial Aquifer should dominate nearly all mixing scenarios (except where the water level in the Jackpile Aquifer is above that of the Alluvial Aquifer) (Ref. 35, p. 2752). This is demonstrated by ground water monitoring data from Test Well number 1 from the Hydro-Search (1979) study; this well is screened across the Alluvial and Jackpile aquifers, but the water chemistry plots with the Alluvial Aquifer water on a Piper water chemistry diagram (Ref. 35, pp. 2752, 2871).

Historically, Hydro-Search (1979) used ground water and surface water elevation data, as well as qualitative field observations, to conclude that Rios Paguate and Moquino lose water to the Alluvial Aquifer in the up-gradient areas to a point approximately 1,500 feet above their confluence. Below this point (approximately 5,925 feet above mean sea level), the river system receives water from the Alluvial Aquifer (Ref. 35, pp. 2763, 2865-2869). The USGS (1985) confirmed this observation through its own calculations, using the same data set (Ref. 35, pp. 2763, 2838-2839. A similar study conducted by Hydro-Search in July 1981, during "a period of high evapotranspiration," indicated that the area near the confluence loses water, suggesting a seasonal variation is the gain/loss of the river through this area. No detailed study to date has shown whether this is a regular, or seasonal, variation (Ref. 7, p. 5; Ref. 35, p. 2763). Hydrologic models by Dames and Moore (1983) and the USGS (1985) predict that surface water should be in intimate contact with ground water. The hydraulic coefficient of the alluvium is 23 feet per day at the confluence of Rios Paguate and Moquino (USGS 1983), and should be even higher in areas where the alluvium has been replaced by overburden and tailings (Ref. 35, pp. 2763, 2838).

Currently, geologic cross sections completed through the property based on measurements collected during the April 2011 ESI, indicate that surface water may have flowed into the North and South Paguate pits, causing ground water to rebound more quickly than modeled. Ground water elevations indicate that ground water from the North Paguate and Jackpile pits is flowing into Rio Moquino. Ground water from the South Paguate Pit appears to be flowing into Rio Paguate, and water from Rio Paguate (and/or the associated Alluvial Aquifer) may be flowing into the North Paguate Pit (Ref. 35, pp. 2766, 2767, 2773).

# 4.0 SURFACE WATER MIGRATION PATHWAY

## 4.1 OVERLAND/FLOOD MIGRATION COMPONENT

### 4.1.1 General Considerations

#### 4.1.1.1 Definition of Hazardous Substance Migration Path for Overland/Flood Component

The hazardous substance migration path includes the in-water segment that hazardous substances would take as they migrate away from sources at the facility (Ref. 1, Section 4.1.1.1). The hazardous substance migration path for in-water segments for the sources are described below. The surface water pathway is presented on Figures A-3 and A-4.

**Overland and In-Water Segments**

The mine facility and surrounding areas are drained by Rio Paguate and Rio Moquino. The Rio Paguate flows from headwaters located approximately 10 miles above the mine facility, through Bear Canyon, into the watershed that covers much of the eastern flank of Mt. Taylor. The source waters originate through seeps from Quaternary basalts capping Mesa Chivato, as well as Quaternary alluvium along the canyon. The Rio Moquino flows from headwaters located approximately 3.5 miles above the mine facility in Seboyeta Canyon. Like the Rio Paguate, the source waters originate through seeps from Cretaceous sandstones, Quaternary basalt and alluvium in the upper reaches of the watershed (Ref. 35, pp, 2753, 2813, and 2877). The Rio Paguate is joined by the Rio Moquino near the center of the mine facility. Below this confluence, the Rio Paguate flows southeasterly into Paguate Reservoir before joining the Rio San Jose 5 miles south of the mine facility (Ref. 4, p. 101). The Rio Paguate has been rechanneled for more than 2,000 feet downstream of its entrance to the mine facility (Ref. 4, p. 101). The Rio Moquino has been extensively modified over a 4,000-foot segment immediately above its confluence with the Rio Paguate. Waste material has been dumped into the original channel on both sides, straightening the course of the meandering stream (Ref. 4, p. 102). At the mine facility, both streams usually flow all year (perennially); however, south of the mine facility, the Rio Paguate acts as an ephemeral stream becoming intermittently dry (Ref. 4, p. 103).

For HRS purposes, in areas in which the average annual rainfall is less than 20 inches, eligible rivers include those that have been determined to be intermittently flowing water and contiguous intermittently flowing ditches (Ref. 1, Sec. 4.02). The average annual rainfall at the Jackpile-Paguate Uranium Mine facility is approximately 9 to 12 inches (Ref. 22, pp. 15-16).

Flow in Rio Paguate and Rio Moquino is generally moderate from January to March, elevated in March and April, low during the summer months, and moderate from October through December. Short-term peak flows occur in the summer in response to thunderstorms. The highest flow recorded on the Rio Paguate was estimated to be 2,300 cubic feet per second (cfs) (USDI, Geological Survey 1967). Flood estimates of peak discharges at the southern mine boundary are 1,520 cfs for a 5-year flood; 6,290 cfs for a 100-year flood, and 10,500 cfs for a 500-year flood (Ref. 4, p. 103).

The Rio Moquino and Rio Paguate bisect the mine and are in direct contact with the sources (Ref. 3, p. 1; Ref. 7, p. 10). Within the mine footprint, ground water in the Jackpile sandstone interchanges with water in the Rio Moquino and Rio Paguate through the unconsolidated alluvium deposits along the stream channels. The stream deposits act as a mixing zone between the surface water in the rivers and the ground water discharging from the underlying Jackpile sandstone (Ref. 7, pp. 5, 26).

The in-water segment begins in the most upstream Probable Point of Entry (PPE) to an eligible surface water body as defined in the HRS (Ref. 1, Sec. 4.02). Eligible surface water bodies that have been determined to be part of the in-water segments for the Jackpile-Paguate Uranium Mine facility include Rio Moquino, Rio Paguate, Paguate Reservoir, and Rio San Jose (Figure A-3). Rationale for including these eligible surface water bodies is provided below. There are multiple PPEs for each source identified (Ref. 3, p. 1; Figure A-3). The PPEs presented in this documentation record are located where each indentified pit or waste dump is closest to either the Rio Paguate or Rio Moquino (see Figure A-3).

The target distance limit (TDL) for the surface water pathway, which defines the maximum distance over which targets are considered, is 15 miles. The TDL is defined as being 15 miles from the farthest downstream PPE in the in-water segment section. The 15-mile surface water flow path is presented in Figure A-4 (Ref. 1, Sec. 4.1.1.2).

Drainage from Source 1 and Source 2 enters the Rio Moquino and Rio Paguate at PPEs 1 through PPE 4 **(**refer to Figure A-3). The slope from each source is towards Rio Paguate and Rio Moquino (Ref. 3, p. 1). PPE1 is the closest point of entry from the South Paguate Pit to Rio Paguate with an overland flow distance of approximately 1,100 feet (Ref. 40, pp. 1,2). PPE2 is the closest point of entry from the North Paguate Pit to Rio Paguate with an overland flow distance of approximately 150 feet (Ref. 40, pp. 1,2). PPE3 is the closest point of entry from Waste Dump V to Rio Moquino with a minimal (>0) overland flow distance (Ref. 40, pp. 1, 2). PPE4 is the closest point of entry from Jackpile Pit to Rio Paguate with an overland flow distance of approximately 840 feet (Ref. 40, pp. 1, 2). From PPE1, Rio Paguate flows approximately 1 mile before converging with Rio Moquino. From PPE2, Rio Paguate flows approximately 0.7 miles before converging with Rio Moquino. From PPE3, Rio Moquino flows approximately 600 feet before converging with Rio Paguate. From the convergence, Rio Paguate flows south approximately 1 mile before PPE4. From PPE4 Rio Paguate flows approximately 4.2 miles before entering the Paguate Reservoir and the Mesita Dam. The Paguate Reservoir is approximately 0.5 miles long, and then the Rio Paguate continues an additional 0.6 miles before converging with and becoming the Rio San Jose. The Rio San Jose continues for the remaining 15-mile TDL (Ref. 3, pp. 1 to 3; Ref. 12). Within the in-water segment of the TDL, there are two Level II fisheries which have been identified between the PPEs and the location where sample PR-SW-01 was collected within the northern portion of the Paguate Reservoir (Ref. 23, Figure A-3). There is also a potential fishery within the southern portion of the Paguate Reservoir to the Rio San Jose downstream to the TDL (Ref. 23, Figure A-3).

Surface waters from the Rio Paguate and Rio Moquino are used for irrigation upstream from the villages of Paguate and Seboyeta, respectively. Surface water is also consumed by livestock from the Paguate Reservoir and along the Rio Paguate between the reservoir and the mine facility at points of access (Ref. 4, p. 104). The Rio Paguate is designated by the New Mexico Water Quality Control Commission for the following uses: domestic water supply, fish, culture, high-quality coldwater fishery, irrigation, livestock, and wildlife watering, and secondary contact recreation (Ref. 4, p. 106).

Surface waters are not regularly used for human consumption in the Paguate-Laguna area; however, part of the surface water passing through the mine facility collects downstream in the Paguate Reservoir. Water from this reservoir is used as drinking water by livestock, so a potential pathway exists for indirect exposure (Ref. 4, p. 98).

### 4.1.2.1 LIKELIHOOD OF RELEASE

#### 4.1.2.1.1 Observed Release

**Direct Observation**

Observed release can be established by direct observation. Material containing hazardous substances is in direct contact with the surface water and has been seen entering the surface water pathway through direct disposition.

The Rio Moquino has been extensively modified over a 4,000-foot segment immediately above its confluence with the Rio Paguate. Waste material has been dumped into the original channel on both sides, straightening the course of the meandering stream (Ref. 4, p. 102).

During the March 2010 SI sampling activities, sample JM-SS-03 was collected on the bank of the Rio Moquino and close to surface water sample RM-JM-SW (Figure A-5A; Ref. 19, pp. 21, 22; Ref. 30, pp. 76, 77). According to Laguna officials, the river banks were not reclaimed and source materials are present there (Ref. 19, p. 5). Source sample JM-SS-03 was collected during draught conditions and therefore was not in direct contact with the surface water. However, after rain events, the Rio Moquino would contain water such that sample location JM-SS-03 would be in direct contact with the surface water (Ref. 19, pp. 4, 6, 7). Sample JM-SS-03 contained elevated concentrations of total uranium at 127 ppm (Ref. 20, pp. 172, 1210; Ref. 26, 1 to 3). The surface water samples collected within the Rio Moquino adjacent to this sample contained total uranium at 16.8 ppb, 109 ppb and 78.9 ppb (Ref. 19, p. 22; Ref. 20, pp. 22, 75, 1190, 1219; Ref. 25, pp. 1 to 5; Ref. 26, pp 1 to 3; Ref. 35, pp. 96, 772-773, 1587). These concentrations were greater than background concentrations found within Rio Moquino (sample RM-SW-BG) (Ref. 19, p. 18; Ref. 20, pp. 18, 70, 557, 580,711,782,1203; Ref. 25, pp. 1 to 5, 45 to 49; Ref. 26, pp. 1 to 3; Ref. 35, pp. 87-88, 774, 1587).

During the April 2011 ESI sampling event, START-3 personnel found radiation readings greater than 999 microRem per hour (uR/h) using a Ludlum Radiation meter along the banks of Rio Paguate just upstream of the confluence of the Rio Paguate and the Rio Moquino (Ref. 35, p. 96). Rocks containing oxidized uranium could also be seen along the river bank where the high radioactive readings were detected (Ref. 35, pp. 67, 68).

## Chemical Analysis

Sediment and surface water samples were collected during the March 2010 EPA SI and April 2011 EPA ESI (Ref. 8, p. 6; Ref. 19; Ref. 35, p. 114). Sediment and surface water samples during the March 2010 sampling event were collected from the surface water pathway at 9 locations in the Rio Moquino, Rio Paguate, and Paguate Reservoir (Ref. 8, p. 27). During the April 2011 sampling event, surface water samples were collected from 8 locations and sediment samples were collected from 9 locations in the Rio Moquino, Rio Paguate, and Paguate Reservoir (Ref. 36, p. 4). Sample locations are depicted in Figures A-5A and A-5B.

**Background Concentrations:**

Background sediment and surface water samples were collected from the locations listed below to investigate whether a release from the facility could be established (Ref. 8, Ref. 19; Ref. 35, p. 118).

- **Rio Moquino** - Two background sediment samples and two surface water samples were collected from Rio Moquino during the March 2010 and April 2011 sampling events (RM-SW-BG, RM-SED-BG, RM-SW-BG-110419, RM-SED-BG-110419) immediately upstream of the Jackpile-Paguate Uranium Mine before confluence with the Rio Paguate. The background sediment sample and surface water samples collected from Rio Moquino is compared to facility-related sediment and surface water samples collected from Rio Moquino, Rio Paguate and the Paguate Reservoir.

- **Rio Paguate –** Two background sediment samples and two surface water samples were collected from Rio Paguate (during the March 2010 and April 2011 sampling events (RP-SW-BG, RP-SED-BG, RP-SW-BG-041911, RP-SED-BG-041911) immediately upstream of the Jackpile-Paguate Uranium Mine before confluence with the Rio Moquino. The background sediment sample and surface water samples collected from Rio Paguate is compared to site-related sediment and surface water samples collected from Rio Moquino, Rio Paguate, and the Paguate Reservoir.

- **Mesita Diversion** – One sediment sample (MD-SW-110420) was collected off the Rio San Jose from an irrigation diversion ditch in April 2011 to determine regional background levels and was used in standard deviation background calculations for radionuclide concentrations from the Rio Moquino, Rio Paguate and Paguate Reservoir.

The topographic map of the area indicates the presence of surface water bodies for which there are no background samples. Arroyo Moquino, which appears to be an intermittent stream that flows through the mine into Rio Paguate just below the Rio Paguate and Rio Moquino confluence, no longer converges with the Rio Paguate and therefore was not considered an appropriate background location (Ref. 3; Ref. 19, p. 4). Another intermittent stream, Oak Canyon, exists south of the facility and flows into Rio Paguate at a point just north of the Paguate Reservoir (Ref. 3). According to the Pueblo of Laguna Environmental and Natural Resources Department, Oak Canyon is an arroyo with no regular flow and contains run-off water from rain events. Due to the topography of the area, there is no way to access Oak Canyon to obtain a background sample. Upon further review of possible sources within the vicinity of the Jackpile-Paguate Mine, there are no other potential sources of contamination located

upstream of Oak Canyon. The closest mine in the area, St. Anthony, drains into Arroyo Conchas located northeast of the Jackpile-Paguate Uranium Mine (Ref. 3; Ref. 19, p. 3)

According to the QASPs for the property, the Rio Moquino and Rio Paguate background sampling locations were collected immediately upstream of the Jackpile-Paguate Uranium Mine for the purposes of collecting samples unaffected by the mine facility and to establish background concentrations of the local area (Ref. 30, p. 23; Ref. 35, p. 118; Figures A-5A, A-5B).

The background sediment samples were collected on 02 March 2010 and 19 April 2011 by START-3 with disposable plastic scoops, in accordance with the approved QASPs, and then transferred to an 8-ounce sample container (Ref. 8, pp. 15, 17; Ref. 30, p. 18; Ref. 35, p. 121; Ref. 36, p. 4). The sediment samples were collected from 0 to 2 inches below ground surface (Ref. 19, p. 29; Ref. 35, pp. 222-223; Ref. 36, p. 4). The samples were collected from locations within the creek channel where sediments had accumulated, such as bends in the creek (Ref. 8; Ref. 35, pp. 222-223; Ref. 36, p. 4). The background surface water samples were collected by submerging the sample container into the water and facing the mouth of the container upstream while sampling personnel stood downstream (Ref. 8, p. 113; Ref. 36, p. 4). The March 2010 samples were shipped via Federal Express to ALS Laboratory Group located in Fort Collins, Colorado (Ref. 8, p. 16; Ref. 19, pp. 11, 23). The April 2011 samples were hand delivered to Summit Laboratory, located in Albuquerque, New Mexico on 22 April 2011 (Ref. 36, p. 5). The March 2010 samples were analyzed for total metals by EPA Methods SW-846 3005A(liquid) 3050B (solid) and 6010B, total cyanide by EPA Methods SW-846 9010 and 9014, mercury by EPA Methods SW-846 7470A/7471A and SOP812 Rev. 14, and isotopic uranium by SOP778R13 and SOP714R11 (Ref. 20, pp. 13, 51, 542, 720, 758, 1170). The April 2011 samples were analyzed for: isotopic uranium (isotopes 234, 235, and 238) by method Eichrom ACW-03-15 and ACW-10; total metals by EPA method 200.7 for water and 6010B for solids; selenium by EPA method 6020; mercury by EPA method 7470A/7471A; Radium$^{226}$ by EPA method 903; and Radium$^{228}$ by EPA method 904. In addition, all water samples were also analyzed for: alkalinity by method SM2310-B; bicarbonate by method SM-17 2320; carbonate by method SM 4500-CO2D; Total Dissolved Solids by method SM 2540-C; and anions by EPA method 300 (Ref. 36, pp. 5).Once final analytical results were received, the data underwent third-party data review and validation by a START-3 chemist not associated with the sampling conducted at the facility (Ref. 25; Ref. 36, p. 5).

The background samples (surface water and sediment) and the samples collected to demonstrate an observed release were all collected during the same time frames during the same sampling events (Ref. 36, p. 4). The samples were collected by the same field teams during the same sampling events, following the same sample collection protocols and methodologies. Background samples were collected from similar locations, were from similar media, same depth, under the same hydrological conditions and flow, used the same sampling methods, preservation, and handling and were all collected during the same weather conditions as the observed release samples (Ref. 35, pp. 87-96; Ref. 36, pp. 7-16).

No sediment samples were evaluated as observed release samples and therefore are not included in further discussion of background or observed release samples.

## EPA SI Background Surface Water Sampling – March 2010

| Station Location | Sampling Location | Sample Date (Military Time) | Reference |
|---|---|---|---|
| **Rio Moquino** | | | |
| RM-SW-BG | Rio Moquino upstream of the Jackpile-Paguate Uranium Mine and of the confluence with Rio Paguate | 03/02/10 (1012) | Ref. 19, p. 18, Figure A-5A |
| **Rio Paguate** | | | |
| RP-SW-BG (Duplicate) RP-SW-BGD (Duplicate) | Rio Paguate upstream of the Jackpile-Paguate Uranium Mine and of the confluence with Rio Moquino | 03/02/10 (0929) | Ref. 19, p. 18, Figure A-5A |

## EPA SI Background Surface Water Sample Concentrations – March 2010

| Station Location | Hazardous Substance | Concentration (mg/l)[1] | Reporting Limit[2] | Reference |
|---|---|---|---|---|
| **Rio Moquino** | | | | |
| RM-SW-BG | Manganese | 0.027 | 0.01 | Ref. 19, p. 18; Ref. 20, pp. 18, 70; Ref. 25, pp. 1 to 5 |
| **Rio Paguate** | | | | |
| RP-SW-BG | Manganese | 0.045 | 0.01 | Ref. 19, p. 18; Ref. 20, pp. 20, 73; Ref. 25, pp. 1 to 5 |
| RP-SW-BGD (Duplicate) | Manganese | 0.044 | 0.01 | Ref. 19. p.18; Ref. 20, pp. 20, 74; Ref. 25, pp. 1 to 5 |

Notes:
[1] mg/l – milligram per liter
[2] The definition of the Reporting Limit used by ALS Laboratory Group was not provided in the laboratory package (Ref. 20, pp. 758 to 762).

Samples collected during the March 2010 sampling event from Rio Moquino, Rio Paguate and Paguate Reservoir is compared to the highest designated background level as shown below:

## Significant Background Concentration – March 2010

| Matrix | Hazardous Substance | Highest Background Concentration (mg/l)[1] | 3 x Background |
|---|---|---|---|
| Surface Water | Manganese | 0.045 | 0.135 |

Notes:
[1] mg/l – milligram per liter

## EPA ESI Background Surface Water Sampling – April 2011

| Station Location | Sampling Location | Sample Date (Military Time) | Reference |
|---|---|---|---|
| **Rio Moquino** | | | |
| RM-SW-BG-110419 | Rio Moquino upstream of the Jackpile-Paguate Uranium Mine and of the confluence with Rio Paguate | 04/19/11 (14:25) | Ref. 35, p.88, Figure A-5B |
| **Rio Paguate** | | | |
| RP-SW-BG-041911 | Rio Paguate upstream of the Jackpile-Paguate Uranium Mine and of the confluence with Rio Moquino | 04/19/11 (10:25) | Ref. 35, p.86, Figure A-5B |
| **Mesita Diversion** This sample location was collected to determine regional background levels and was only used in standard deviation background calculations for radionuclide concentrations | | | |
| MD-SW-110420 | Mesita Diversion where water is collected from the Rio San Jose to irrigate crops for Mesita Village. | 04/20/11 (1415) | Ref. 35, p.93, Figure A-5B |

## EPA ESI Background Surface Water Sample Concentrations – April 2011

| Station Location | Hazardous Substance | Concentration | Reporting Limit[2] | Units[1] | Reference |
|---|---|---|---|---|---|
| **Rio Moquino** | | | | | |
| RM-SW-BG-110419 | $Uranium^{234}$<br>$Uranium^{235}$<br>$Uranium^{238}$ | 4.119<br>0.0996<br>2.230 | 0.066<br>0.019<br>0.066 | pCi/l<br>pCi/l<br>pCi/l | Ref. 35, pp. 744, 774, 1587 |
| **Rio Paguate** | | | | | |
| RP-SW-BG-041911 | $Uranium^{234}$<br>$Uranium^{235}$<br>$Uranium^{238}$ | 6.242<br>0.216<br>3.793 | 0.061<br>0.018<br>0.041 | pCi/l<br>pCi/l<br>pCi/l | Ref. 35, pp. 747, 778, 1587 |
| **Mesita Diversion** | | | | | |
| MD-SW-110420 | $Uranium^{234}$<br>$Uranium^{235}$<br>$Uranium^{238}$ | 4.858<br>0.306<br>2.811 | 0.054<br>0.016<br>0.070 | pCi/l<br>pCi/l<br>pCi/l | Ref. 35, pp. 736, 760, 1587 |

Notes:
1 pCi/l = picocurie per liter
2 The Reporting Limit is defined as the MDC for uranium by Alpha Spectroscopy and is the net concentration that has a specified chance of being detected (Ref. 39, p. 3).
3 Radiological data were validated by a START-3 Certified Health Physicist with 30 years of radiation characterization experience. Data for target analytes meet the definitive data quality objective (Ref. 35, p. 1587, Ref. 36, p. 5).

Samples collected during the April 2011 sampling event from Rio Moquino, Rio Paguate and Mesita Diversion (for standard deviation calculations) is compared against the designated background levels as shown below:

## Significant Background Concentrations - April 2011

| Sample ID | Hazardous Substance | Conc. | Units | Sample Mean | Sample Variance[1] | Sample Standard Deviation[2] | 2 Standard Deviations Above The Mean |
|---|---|---|---|---|---|---|---|
| MD-SW-110420 | Uranium$^{234}$ | 4.858 | pCi/l | 5.073 | 1.161451 | 1.077706361 | 7.228412721 |
| RM-SW-BG-110419 | Uranium$^{234}$ | 4.119 | pCi/l | | | | |
| RP-SW-BG-041911 | Uranium$^{234}$ | 6.242 | pCi/l | | | | |
| MD-SW-110420 | Uranium$^{235}$ | 0.306 | pCi/l | 0.2072 | 0.01070832 | 0.103481013 | 0.414162026 |
| RM-SW-BG-110419 | Uranium$^{235}$ | 0.0996 | pCi/l | | | | |
| RP-SW-BG-041911 | Uranium$^{235}$ | 0.216 | pCi/l | | | | |
| MD-SW-110420 | Uranium$^{238}$ | 2.811 | pCi/l | 2.94466667 | 0.624142333 | 0.790026793 | 4.524720252 |
| RM-SW-BG-110419 | Uranium$^{238}$ | 2.23 | pCi/l | | | | |
| RP-SW-BG-041911 | Uranium$^{238}$ | 3.793 | pCi/l | | | | |

**Note:**

[1] Equation for sample variance = $\frac{1}{n-1}\sum_{i=1}^{n}(X_i - \overline{X})^2$

[2] Equation for population standard deviation = square root of the population variance.

(a) The result was reported as a non-detect (3.58 U pCi/l). A value of 1/2 the reporting limit was used in the calculation of the population standard deviation.

**Observed Release Samples:**

Sediment and surface water samples identified as "contaminated" are those that meet observed release criteria as defined by the HRS (Ref. 1, Table 2-3). Observed release criteria is met when the hazardous substance is attributable to a release from the property, its concentration exceeds the Sample Quantitation Limit (SQL; including the background SQL), and is at least three times greater than the background concentration when the background concentration equals or exceeds its SQL for non-radionuclides (Ref. 1, Table 2-3). For radionuclides that occur naturally or are ubiquitous to the environment, observed release criteria is met when the measured concentration (in units of activity) are at a level that equals or exceeds a value 2 standard deviations above the mean site-specific background concentration for the radionuclide in a specific matrix (Ref. 1, Section 7.1.1). Surface water sampling locations with concentrations meeting observed release criteria are presented in the table below.

**Observed Release Sampling Locations**

| Station Location | Sampling Location | Sample Date (Military Time) | Reference |
|---|---|---|---|
| **EPA SI Surface Water Sampling – March 2010** | | | |
| RM-JM-SW | Rio Moquino, within the property, upstream of its confluence with Rio Paguate and 5,500 feet south of the Jackpile-Paguate Mine boundary at PPE3 | 3/3/10 (1529) | Ref. 12; Ref. 19, p. 22 |
| RP-JM-SW | Rio Paguate, within the property, just upstream of its confluence with Rio Moquino and 6,800 feet east of the Jackpile-Paguate Mine boundary and 4,900 feet from PPE1 | 3/3/10 (1432) | Ref. 12; Ref. 19, p. 21 |
| RP-JM-SW-01 | Rio Paguate, within the property, just downstream of the confluence of Rio Moquino and Rio Paguate, 600 feet from PPE3 | 3/3/10 (1511) | Ref. 12; Ref. 19, p. 21 |
| RP-SW-01<br>RP-SW-01D (Duplicate) | Rio Paguate at the south property boundary, at PPE4 (the furthest downstream PPE) | 3/3/10 (1135) | Ref. 12; Ref. 19, p. 34 |
| RP-SW-02 | Rio Paguate, 9,500 feet. downstream of PPE4 | 3/3/10 (1030) | Ref. 12; Ref. 19, p. 34 |
| RP-SW-03 | Rio Paguate, on north side of Paguate reservoir, 21,600 feet downstream of PPE4 | 3/2/10 (1710) | Ref. 12; Ref. 19, p. 19 |
| PR-SW-01 | Paguate Reservoir, 22,300 feet downstream of PPE4 | 3/2/10 (1526) | Ref. 12; Ref. 19, p. 32 |
| **EPA ESI Surface Water/Sediment Sampling – April 2011** | | | |
| RM-JM-SW-110420<br>RM-JM-SW-02 (duplicate) | Rio Moquino, within the property, upstream of its confluence with Rio Paguate and 5,500 feet south of the Jackpile-Paguate Mine boundary at PPE3 | 4/20/11 (1705-SW, 1710-SW DUP) | Ref. 12; Ref. 35, pp. 96, 118 |

| Station Location | Sampling Location | Sample Date (Military Time) | Reference |
|---|---|---|---|
| RP-JM-SW-110420 | Rio Paguate, within the property, just upstream of its confluence with Rio Moquino and 6,800 feet east of the Jackpile-Paguate Mine boundary and 4,900 feet from PPE1 | 4/20/11 (1615-SW | Ref. 12; Ref. 35, pp. 94-95, 118 |
| RP-JM-SW-01-110420 | Rio Paguate, within the property, just downstream of the confluence of Rio Moquino and Rio Paguate, 600 feet from PPE3 | 4/20/11 (1540-SW | Ref. 12; Ref. 35, pp. 94, 118 |
| RP-SW-01-110419 | Rio Paguate, 9,500 feet. downstream of PPE4 | 4/19/11 (1540-SW) | Ref. 12; Ref.35, pp. 89, 118 |
| PR-SW-01-110420 | Paguate Reservoir, 22,300 feet downstream of PPE4 | 4/20/11 (1135-SW) | Ref. 12; Ref. 35, pp. 92-93, 118 |

All observed release samples were collected by START-3 on 02 through 04 March 2010 and from 19 through 20 April 2011 (Ref. 19; Ref. 35, pp. 85-98). The sediment samples were collected by START-3 with disposable plastic scoops, in accordance with the approved QASPs, and then transferred to an 8-ounce sample container (Ref. 8, pp. 15, 17; Ref. 30, p. 18; Ref. 35, p. 121; Ref. 36, p. 4). The surface water samples were collected by submerging the sample container into the water and facing the mouth of the container upstream while sampling personnel stood downstream (Ref. 8, p. 113; Ref. 36, p. 4).

The samples were analyzed using established EPA methodologies and laboratory Standard Operation Procedures (SOPs). The March 2010 samples were shipped via Federal Express to ALS Laboratory Group located in Fort Collins, Colorado (Ref. 8, p. 16; Ref. 19, pp. 11, 23). The April 2011 samples were hand delivered to Summit Laboratory, located in Albuquerque, New Mexico on 22 April 2011 (Ref. 36, p. 4). The March 2010 samples were analyzed for total metals by EPA Methods SW-846 3005A(liquid) 3050B (solid) and 6010B, total cyanide by EPA Methods SW-846 9010 and 9014, mercury by EPA Methods SW-846 7470A/7471A and SOP812 Rev. 14, and isotopic uranium by SOP778R13 and SOP714R11 (Ref. 20, pp. 13, 51, 542, 720, 758, 1170). The April 2011 samples were analyzed for: isotopic uranium (isotopes 234, 235, and 238) by method Eichrom ACW-03-15 and ACW-10; total metals by EPA method 200.7 for water and 6010B for solids; selenium by EPA method 6020; mercury by EPA method 7470A/7471A; Radium$^{226}$ by EPA method 903; and Radium$^{228}$ by EPA method 904. In addition, all water samples were also analyzed for: alkalinity by method SM2310-B; bicarbonate by method SM-17 2320; carbonate by method SM 4500-CO2D; Total Dissolved Solids by method SM 2540-C; and anions by EPA method 300 (Ref. 36, pp. 5).Once final analytical results were received, the data underwent third-party data review and validation by a START-3 chemist not associated with the sampling conducted at the property (Ref. 25; Ref. 36, p. 5).

## Surface Water Sample Concentrations – March 2010

| Station Location | Hazardous Substance | Concentration (mg/l)[1] | Reporting Limit[2] | Reference |
|---|---|---|---|---|
| **EPA SI[3]** | | | | |
| **Rio Paguate** | | | | |
| RP-JM-SW | Manganese | 0.14 | 0.01 | Ref. 19, p. 21; Ref. 20, pp. 726, 777; Ref. 25, pp. 1 to 5 |
| PR-SW-01 | Manganese | 0.25 | 0.01 | Ref. 19, p. 34; Ref. 20, pp. 22, 75; Ref. 25, pp. 1 to 5 |
| RP-SW-01 | Manganese | 0.19 | 0.01 | Ref. 19, p. 34; Ref. 20, pp. 714, 780; Ref. 25, pp. 45 to 49 |
| **Paguate Reservoir** | | | | |
| RP-SW-01D | Manganese | 0.19 | 0.01 | Ref. 19, p. 34; Ref. 20, pp. 714, 771; Ref. 25, pp. 45 to 49 |

Notes:
[1] mg/kg - milligram per liter (mg/l)
[2] The definition of the Reporting Limit used by ALS Laboratory Group was not provided in the laboratory package (Ref. 20, pp. 758 to 762).
[3] Chemical laboratory data collected during EPA SI and ESI activities were validated by a START-3 chemist in accordance with *EPA USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review* (July 2002), and the Regional Protocol for Holding Times, Blanks, and VOA Preservation (April 13, 1989). Data for target analytes meet the definitive data quality objective (Ref. 25, pp. 5, 36, 49, 74).

## Surface Water Sample Concentrations – April 2011

| Station Location | Hazardous Substance | Concentration (pCi/l)[1] | Reporting Limit[2] | Reference |
|---|---|---|---|---|
| **EPA ESI[3]** | | | | |
| **Rio Moquino** | | | | |
| RM-JM-SW-110420 | $Uranium^{234}$<br>$Uranium^{235}$<br>$Uranium^{238}$ | 37.997<br>1.540<br>33.431 | 0.141<br>0.029<br>0.101 | Ref. 35, pp. 96, 743, 772, 1587 |
| RM-JM-SW-02-110420 | $Uranium^{234}$<br>$Uranium^{235}$<br>$Uranium^{238}$ | 28.334<br>0.961<br>23.591 | 0.038<br>0.044<br>0.011 | Ref. 35, pp. 96, 743, 772, 1587 |
| **Rio Paguate** | | | | |
| RP-JM-SW-110420 | $Uranium^{234}$<br>$Uranium^{235}$<br>$Uranium^{238}$ | 28.476<br>1.071<br>24.247 | 0.056<br>0.043<br>0.075 | Ref. 35, pp. 94-95, 746, 776, 1587 |
| RP-JM-SW-01-110420 | $Uranium^{234}$<br>$Uranium^{235}$<br>$Uranium^{238}$ | 32.398<br>1.236<br>29.257 | 0.070<br>0.034<br>0.052 | Ref. 35, pp. 94, 745, 775, 1587 |
| RP-SW-01-110420 | $Uranium^{234}$<br>$Uranium^{235}$<br>$Uranium^{238}$ | 85.098<br>3.236<br>78.787 | 0.031<br>0.011<br>0.025 | Ref. 35, pp. 89, 747, 777, 1587 |
| **Paguate Reservoir** | | | | |
| PR-SW-01-110420 | $Uranium^{234}$<br>$Uranium^{235}$<br>$Uranium^{238}$ | 17.445<br>0.565<br>14.624 | 0.141<br>0.029<br>0.101 | Ref. 35, pp. 92-93, 740, 769, 1587 |

Notes:
[1] pCi/l = picocurie per liter
[2] The Reporting Limit is the MDC, the net concentration that has a specified chance of being detected for uranium by Alpha Spectroscopy

(Ref. 39, p. 3).

[3] Radiological data were validated by a START-3 Certified Health Physicist with 30 years of radiation characterization experience. Data for target analytes meet the definitive data quality objective (Ref. 35, p. 1587; Ref. 36, p. 5).

The metal analysis for samples collected in March 2010 was not of dissolved metals, and field filtration of the surface water samples was not performed. Both sediment and surface water samples were collected from each surface water pathway sample location. The sediment samples from March 2010 did not exhibit metal concentrations at observed release concentrations indicating that the metal concentrations present in the surface water samples were not due to the sediments (Ref. 30, pp. 86 to 88). All water samples collected April 2011 were field filtered using 0.45 micrometer (µm) filter paper (Ref. 36, p. 4).

The background samples and observed release samples were both collected from the same medium on 02 through 04 March 2010 or 19 through 20 April 2011, by the same START-3 teams operating under the same QASPs and sampling procedures. Background and observed release samples were collected from similar locations, were from similar media, same depth, used the same sampling methods, preservation, and handling and were all collected during the same weather conditions (Ref. 8; Ref; 19; Ref. 30, p. 18; Ref. 35, pp. 87-96; Ref. 36, pp. 7-16). Both the background samples and observed release samples are of sufficient similarity to document an observed release as defined by the HRS (Ref. 1, Section 4.1.2.1.1).

**Attribution:**

As part of an environmental assessment of the Jackpile-Paguate Uranium Mine facility in March 2010, and April 2011 START-3 collected a total of 7 source samples from former open pit and waste dump locations within the mine area including three solid waste samples, one liquid waste sample, and three subsurface water samples from within the former mine area (Ref. 19, Figure A-5A). The solid waste samples contained uranium$^{238}$ as high as 367 ug/g and manganese as high as 270 mg/kg. The liquid waste sample contained uranium$^{238}$ as high as 114,131 pCi/l and manganese as high as 4.633 mg/l (see Section 2.4.1 of this HRS documentation record). These same contaminants have been found as observed release samples in the surface water pathway as high as 78.787 pCi/l for uranium$^{238}$ and 0.25 mg/l for manganese (see Section 2.4.1.2.1.1 of this HRS documentation record).

The sources at the facility are uncontained, and even in places are in the surface water. The Rio Paguate has been rechanneled for more than 2,000 feet downstream of its entrance to the mine facility (Ref. 4, p. 101; Ref. 31). The Rio Moquino has been extensively modified over a 4,000-foot segment immediately above its confluence with the Rio Paguate. Waste material has been dumped into the original channel on both sides, straightening the course of the meandering stream (Ref. 4, p. 102). It appears that normal practice was to stockpile waste material in the Rio Moquino's floodplain as records indicate that approximately 500,000 tons of material from Waste Dump U on the east side of the river were removed during 1982, the last year of mining operations (Ref. 4, p. 69). Potential hazards resulting from waste dump instability at the mine include rotational failures, base translational failures, and foundation spreading (Ref. 4, p. 77). Such waste dump failures could expose material and thus present a health and environmental hazard (Ref. 4, p. 77). Limited slope stabilization studies were performed on the slope of Waste Dump I to evaluate the ability of biodegradable matting to inhibit erosion. Special reseeding techniques were performed on the slope of Waste Dump J. The matting and special reseeding techniques were unsuccessful; however, it is unknown if slope stabilization has actually been performed (Ref. 4, p. 69). Rapid surface water flow from flooding of the rivers could expose surface water to sources at the property in addition to accelerated erosion of the waste dumps due to the long, steep slopes of the waste dumps and potential high-intensity rainfall resulting from summer thunderstorms (Ref. 4, p. 116; Ref. 22, p. 2).

Mine waste enters the surface water pathway via two mechanisms. As discussed above, mine waste enters the surface water pathway through direct disposition by overland flow. During the EPA ESI conducted April 2011, it has also been demonstrated that mine waste also enters the surface water pathway through ground water within the mine pits (see Section 2.2 for Source 1 and Section 3). The ground water to surface water mechanism is further discussed in Section 4.2 of this report.

There are other mines in the area, including St. Anthony Mine which is approximately 11,000 feet northeast of Jackpile-Paguate Mine. The St. Anthony Mine does not connect to Rio Paguate, Paguate Reservoir or Rio San Jose surface water pathway being evaluated (Ref. 3, p. 1, Ref. 19, p.3). Also, background samples collected for Jackpile-Paguate Uranium Mine showed low levels (3.86 ppb and 560 ppb) of total uranium and manganese (Ref. 20, pp. 18 to 20, 70, 72-74, 79, 86, 87, 557 to 559, and 561 to 563). A search of the Toxic Release Inventory database was performed within the zip code of the facility location and no other facilities are listed (Ref. 13).

Due to historical operations, one that has demonstrated to cause uranium and manganese contamination, combined with the overall lack of containment of the source at the facility and the fact

that surface water samples meeting observed release criteria are present that support uranium and manganese contamination migration from the sources at the facility into the surface water pathway, the uranium and manganese contamination in the facility can be attributed (wholly or, at least, in part) to the Jackpile-Paguate Uranium Mine facility.

**Likelihood of Release Factor:**

Based on the analytical data and attribution components listed above, uranium$^{234}$, uranium$^{235}$, uranium$^{238}$ and manganese have been documented as the hazardous substances in the observed release to Rio Paguate. Therefore, the observed release factor value of 550 was assigned for Rio Paguate (Ref. 1, Section 4.1.2.1.1).

Likelihood of Release Factor Value: 550

### 4.1.2.1.2 POTENTIAL TO RELEASE

#### 4.1.2.1.2.1 Potential to Release by Overland Flow

Potential to release was not evaluated because an observed release to surface water was established by chemical analysis (see Section 4.1.2.1.1 of this HRS documentation record).

## 4.1.2 DRINKING WATER THREAT

## WASTE CHARACTERISTICS

Evidence of contamination associated with the Sources has been established based on chemical analyses of samples collected from the sources as well as through direct observation (refer to the Attribution section and Section 2.2). Manganese, uranium$^{234}$, uranium$^{235}$, and uranium$^{238}$, were detected in surface water samples collected in Rio Paguate and Paguate Reservoir, establishing an observed release (see Section 4.1.2.1.1).

### 4.1.2.2.1 Toxicity/Persistence/Bioaccumulation

| Hazardous Substance | Source Number | Toxicity Factor Value | Persistence[1] Factor Value | Toxicity/ Persistence/ | Reference |
|---|---|---|---|---|---|
| Chromium | 1 | 10,000 | 1 | 10,000 | Ref. 2, p. 8 |
| Cobalt | 1 | 10 | 1 | 10 | Ref. 2, p. 8 |
| Manganese | 1, 2 | 10,000 | 1 | 10,000 | Ref. 2, p. 10 |
| Vanadium | 1, 2 | 100 | 1 | 100 | Ref. 2, p. 13 |
| Zinc | 1 | 10 | 1 | 10 | Ref. 2, p. 14 |
| Radium$^{226}$ | 1 | 10,000 | 1 | 10,000 | Ref. 2, p. 15 |
| Radium$^{228}$ | 1 | 10,000 | 1 | 10,000 | Ref. 2, p. 15 |
| Thorium$^{228}$ | 1 | 10,000 | 1 | 10,000 | Ref. 2, p. 15 |
| Thorium$^{230}$ | 1 | 10,000 | 1 | 10,000 | Ref. 2, p. 16 |
| Thorium$^{232}$ | 1 | 10,000 | 1 | 10,000 | Ref. 2, p. 16 |
| Uranium$^{234}$ | 1, 2 | 10,000 | 1 | 10,000 | Ref. 2, p. 16 |
| Uranium$^{235}$ | 1, 2 | 10,000 | 1 | 10,000 | Ref. 2, p. 16 |
| Uranium$^{238}$ | 1, 2 | 10,000 | 1 | 10,000 | Ref. 2, p. 16 |

Notes:
[1] All hazardous substances were assigned the same persistence factor value (i.e., 1.0000) for both water body types (river and lake) within the TDL (Ref 1, Table 4-10).

Toxicity/Persistence Factor Value: 10,000

#### 4.1.2.2.2 Hazardous Waste Quantity

| Source No. | Source Hazardous Waste Quantity Value | Containment | | | |
|---|---|---|---|---|---|
| | | Ground Water | Surface Water | Gas | Air Particulate |
| 1 | 967,756.923 | NE | 10 | NE | NE |
| 2 | 43,560 | NE | 10 | NE | NE |
| TOTAL | 1,011,316.923 | | | | |

NE= not evaluated

A hazardous waste quantity of 1,011,316.923 is estimated for all of the Sources at the Jackpile-Paguate Uranium Mine facility which when applied in HRS Table 2-6 yields a pathway hazardous waste quantity of 1,000,000. Also, as documented in Sections 4.1.2.1.1 and 4.1.4.3.1.2 of this HRS documentation record, a fishery is subject to Level II concentrations; therefore, a minimum value of 100 can be assigned for the hazardous waste quantity factor value (Ref. 1, Section 2.4.2.2). A value of 1,000,000 is assigned as the Hazardous Waste Quantity Factor Value since it is the greater value. This hazardous waste value is based on the non-radioactive hazardous substances only and does not include the radioactive substances. This value alone achieves that maximum value allowable and does not require the addition of the separate radioactive substances hazardous waste quantity value (Ref. 1, Section 7.2.5.3, Table 2-6).

Hazardous Waste Quantity Factor Value = 1,000,000

#### 4.1.2.2.3 Waste Characteristics Factor Category Value

Toxicity/Persistence Factor Value: 10,000
Hazardous Waste Quantity Factor Value: 1,000,000

10,000 (Toxicity/Persistence Factor Value) x 1,000,000 (Hazardous Waste Quantity Factor Value) = 1 x $10^{10}$ (maximum of 1 x $10^{8}$ according to HRS Section 4.1.3.2.3)

Hazardous Waste Quantity Assigned Value: 1,000,000

Waste Characteristics Factor Category Value: 100
(Ref 1, Table 2-7)

#### 4.1.2.3 TARGETS

No drinking water population targets were identified.

#### 4.1.2.3.3 RESOURCES

The Rio Paguate is designated by the New Mexico Water Quality Control Commission for the following uses: domestic water supply, fish, culture, high-quality coldwater fishery, irrigation, livestock, and wildlife watering, and secondary contact recreation (Ref. 4, p. 106). According to Laguna Natural Resource officials, there are approximately 1,500 cattle whose only source of drinking water is the surface water from the Rio Paguate and the Paguate Reservoir within the TDL. These cattle are used for meat by the tribe. There are also approximately 800 cow elk that use the surface water for drinking (Ref. 4, pp. 98, 100, 104; Ref. 19, pp. 6, 7). As such, under the HRS, a resources value of 5 is assigned to the surface water, in-water segment of the hazardous substance migration path for the watershed used for watering of commercial livestock (Ref. 1, Section 4.1.2.3.3).

Resources Factor Value: 5

### 4.1.3.2 HUMAN FOOD CHAIN THREAT

### WASTE CHARACTERISTICS

Evidence of contamination associated with the Sources has been established based on chemical analyses of samples collected from the sources as well as through direct observation (refer to the Attribution section and Section 2.2). Manganese, uranium$^{234}$, uranium$^{235}$, and uranium$^{238}$, were detected in surface water samples collected in Rio Paguate and Paguate Reservoir, establishing an observed release (see Section 4.1.2.1.1).

#### 4.1.3.2.1 Toxicity/Persistence/Bioaccumulation

| Hazardous Substance | Source Number | Toxicity Factor Value | Persistence[1] Factor Value | Human Food Chain Bioaccumulation [2] Value | Toxicity/ Persistence/ Bioaccumulation Factor Value | Reference |
|---|---|---|---|---|---|---|
| Chromium | 1 | 10,000 | 1 | 500 | $5 \times 10^6$ | Ref. 2, p. 8 |
| Cobalt | 1 | 10 | 1 | 5,000 | $5 \times 10^4$ | Ref. 2, p. 8 |
| Manganese | 1, 2 | 10,000 | 1 | 50,000 | $5 \times 10^8$ | Ref. 2, p. 10 |
| Vanadium | 1, 2 | 100 | 1 | 500 | $5 \times 10^4$ | Ref. 2, p. 13 |
| Zinc | 1 | 10 | 1 | 5 | 50 | Ref. 2, p. 14 |
| Radium$^{226}$ | 1 | 10,000 | 1 | 0.5 | 500 | Ref. 2, p. 15 |
| Radium$^{228}$ | 1 | 10,000 | 1 | 0.5 | 500 | Ref. 2, p. 15 |
| Thorium$^{228}$ | 1 | 10,000 | 1 | 0.5 | 500 | Ref. 2, p. 15 |
| Thorium$^{230}$ | 1 | 10,000 | 1 | 0.5 | 500 | Ref. 2, p. 16 |
| Thorium$^{232}$ | 1 | 10,000 | 1 | 0.5 | 500 | Ref. 2, p. 16 |
| Uranium$^{234}$ | 1, 2 | 10,000 | 1 | 0.5 | 500 | Ref. 2, p. 16 |
| Uranium$^{235}$ | 1, 2 | 10,000 | 1 | 0.5 | 500 | Ref. 2, p. 16 |
| Uranium$^{238}$ | 1, 2 | 10,000 | 1 | 5,000 | $5 \times 10^8$ | Ref. 2, p. 16 |

Notes:
[1] All hazardous substances were assigned the same persistence factor value (i.e., 1.0000) for both water body types (river and lake) within the TDL (Ref 1, Table 4-10).
[2] Bioaccumulation factor values are assigned from the SCDM (Ref. 2), for the type of water body "Fresh Water", in which the fisheries are located (Ref. 1, Sect. 4.1.3.2.1.3).

Toxicity/Persistence/Bioaccumulation Factor Value: $5 \times 10^8$

#### 4.1.3.2.2 Hazardous Waste Quantity

| Source No. | Source Hazardous Waste Quantity Value | Containment | | | |
|---|---|---|---|---|---|
| | | Ground Water | Surface Water | Gas | Air Particulate |
| 1 | 967,756.923 | NE | 10 | NE | NE |
| 2 | 43,560 | NE | 10 | NE | NE |
| TOTAL | 1,011,316.923 | | | | |

NE= not evaluated

A hazardous waste quantity of 1,011,316.923 is estimated for all of the Sources at the Jackpile-Paguate Uranium Mine facility which when applied in HRS Table 2-6 yields a pathway hazardous waste quantity of 1,000,000. Also, as documented in Sections 4.1.2.1.1 and 4.1.4.3.1.2 of this HRS documentation record, a fishery is subject to Level II concentrations; therefore, a minimum value of 100 can be assigned for the hazardous waste quantity factor value (Ref. 1, Section 2.4.2.2). A value of 1,000,000 is assigned as the Hazardous Waste Quantity Factor Value since it is the greater value. This hazardous waste value is based on the non-radioactive hazardous substances only and does not include the radioactive substances. This value alone achieves that maximum value allowable and does not require the addition of the separate radioactive substances hazardous waste quantity value (Ref. 1, Section 7.2.5.3, Table 2-6).

Hazardous Waste Quantity Factor Value = 1,000,000

#### 4.1.3.2.3 Waste Characteristics Factor Category Value

Toxicity/Persistence Factor Value: 10,000
Hazardous Waste Quantity Factor Value: 1,000,000
Bioaccumulation Potential Factor Value: 50,000

10,000 (Toxicity/Persistence Factor Value) x 1,000,000 (Hazardous Waste Quantity Factor Value) = $1 \times 10^{10}$ (maximum of $1 \times 10^8$ according to HRS Section 4.1.3.2.3)

$1 \times 10^8$ (Toxicity/Persistence Factor Value x Hazardous Waste Quantity Factor Value) x 50,000 (Bioaccumulation Potential Factor Value) = $5 \times 10^{12}$ (maximum of $1 \times 10^{12}$ according to HRS Section 4.1.3.2.3)

A hazardous waste quantity factor of 1,000,000 is assigned according to HRS Section 2.4.2.2. From Reference 2 and Table 4-12 of the HRS, manganese and uranium$^{238}$ have a toxicity/persistence value of 10,000 and a bioaccumulation potential factor of 50,000. The waste characteristics factor category value from Reference 1, Table 2-7 for a waste characteristics product of $1 \times 10^{12}$ is 1,000.

Hazardous Waste Quantity Assigned Value: 1,000,000
Waste Characteristics Factor Category Value: 1,000

**4.1.3.3 TARGETS**

Level II concentrations in the surface water pathway can be established based on surface water samples that meet the criteria for an observed release and the hazardous substance has a bioaccumulation potential factor value greater or equal to 500 (Ref. 1, Sec. 4.1.3.3). As noted in Sections 4.1.2.1.1 and 4.1.3.2.1 of this HRS documentation record, an observed release of hazardous substances having a bioaccumulation factor value of 500 or greater (uranium$^{238}$ and manganese) is documented in Rio Paguate. A human food chain fishery is present in Rio Paguate within the TDL (Ref. 3, pp. 2, 3; Ref. 23; Figure A-3). According to the Pueblo of Laguna Environmental and Natural Resources Department, Rio Paguate and Rio San Jose are fished for catfish, bluegill, and crappie that are caught for human consumption (Ref. 23). Level II concentrations of manganese, uranium$^{234}$, uranium$^{235}$, and uranium$^{238}$ in surface water samples have been documented within the surface water flow path from samples RM-JM-SW and RP-JM-SW to a distance of 27,800 feet downstream (Ref. 12). The area beginning from the farthest downstream Level II sample location (PR-SW-01) to the 15-mile TDL is subject to potential contamination (refer to Figure A-3).

**EPA SI Surface Water Samples Meeting Observed Release Criteria**
**March 2010**

| Station Location (CLP Sample No.) | Distance From PPE (Feet) | Hazardous Substance | Bioaccumulation Potential Factor Value |
|---|---|---|---|
| RM-JM-SW | At PPE3 | Manganese | 50,000 |
| RP-JM-SW | 3,700 (PPE2) | Manganese | 50,000 |
| RP-JM-SW-01 | 600 (PPE3) | Manganese | 50,000 |
| RP-SW-01<br>RP-SW-01D | At PPE4 | Manganese | 50,000 |
| PR-SW-01 | 22,300 (PPE4) | Manganese | 50,000 |

**EPA ESI Surface Water Samples Meeting Observed Release Criteria**
**April 2011**

| Station Location (CLP Sample No.) | Distance From PPE (Feet) | Hazardous Substance | Bioaccumulation Potential Factor Value |
|---|---|---|---|
| RM-JM-SW | At PPE3 | Uranium$^{234}$<br>Uranium$^{235}$<br>Uranium$^{238}$ | 0.5<br>0.5<br>5,000 |
| RP-JM-SW | 3,700 (PPE2) | Uranium$^{234}$<br>Uranium$^{235}$<br>Uranium$^{238}$ | 0.5<br>0.5<br>5,000 |
| RP-JM-SW-01 | 600 (PPE3) | Uranium$^{234}$<br>Uranium$^{235}$<br>Uranium$^{238}$ | 0.5<br>0.5<br>5,000 |
| RP-SW-01<br>RP-SW-01D | At PPE4 | Uranium$^{234}$<br>Uranium$^{235}$<br>Uranium$^{238}$ | 0.5<br>0.5<br>5,000 |

| Station Location (CLP Sample No.) | Distance From PPE (Feet) | Hazardous Substance | Bioaccumulation Potential Factor Value |
|---|---|---|---|
| PR-SW-01 | 22,300 (PPE4) | $Uranium^{234}$<br>$Uranium^{235}$<br>$Uranium^{238}$ | 0.5<br>0.5<br>5,000 |

**-Closed Fisheries**

No fisheries within the surface water pathway have been closed due to manganese or $uranium^{238}$ contamination.

**-Benthic or Other Tissue**

No benthic or other tissue samples have been collected from the surface water pathway.

#### 4.1.3.3.1 Food Chain Individual

The Rio Paguate's designated uses include cold water aquatic life, domestic water supply, fish culture, irrigation, livestock watering, wildlife habitat, and primary contact according to the EPA (Ref. 11, p. 18). According to the Pueblo of Laguna Environmental and Natural Resources Department, Rio Paguate, the Paguate Reservoir (Mesita Dam) and Rio San Jose are fished for catfish, bluegill, and crappie that are caught for human consumption. The TDL extends from the PPEs to the Rio San Jose, just south of Interstate 40 (refer to Figure A-4). Fishing is documented within the 15-mile TDL (refer to Figure A-3) (Ref. 3, pp. 1 to 3; Ref. 23; Ref. 41). Level II concentrations of uranium$^{238}$ and manganese have been established in Rio Moquino and Rio Paguate to a distance of 27,800 feet from samples RM-JM-SW and RP-JM-SW to the northern part of the Paguate Reservoir (as defined by Level II surface water sample location PR-SW-01) (refer to Figure A-5A).

| Fishery | Type of Surface Water Body | Reference(s) |
|---|---|---|
| Rio Paguate | Minimal Stream | Ref. 7, p. 14 |
| Paguate Reservoir (northern portion) | Lake | Ref. 7, pp. 22 to 24 |

An observed release to Rio Paguate and Paguate Reservoir by chemical analysis has been documented (Ref. 20, pp. 22, 75, 76, 565, 566, 711, 714, 771, 775, 1185, 1191). The release contained uranium$^{238}$ and manganese with a bioaccumulation potential factor value of 50,000. In addition, the release occurred to a watershed containing Level II fisheries within the target distance limit; therefore, a food chain individual value of 45 was assigned (Ref. 1, Section 4.1.3.3.1).

Food Chain Individual Factor Value: 45

#### 4.1.3.3.2 Population

##### 4.1.3.3.2.1 Level I Concentrations

Level I concentrations have not been established as fish tissue samples have not been collected; therefore, the Level I concentrations factor value receives an assigned value of 0.

Level I Concentrations Factor Value: 0

### 4.1.3.3.2.2 Level II Concentrations

| Identity of Fishery | Annual Production (pounds) | Type of Surface Water Body | Average Annual Flow | Reference | Population Value ($P_i$) | Dilution Weight ($D_i$) | $P_i \times D_i$ |
|---|---|---|---|---|---|---|---|
| Rio Paguate | >0, but unknown | Minimal stream | Less than 10 cfs | Ref. 1, Tables 4-13, 4-18; Ref. 15, pp. 1 to 3 | 0.03 | 1 | 0.03 |
| Paguate Reservoir (northern portion) | >0, but unknown | Lake | Less than 10 cfs[1] | Ref. 1, Tables 4-13, 4-18; Ref. 15, pp. 1 to 3 | 0.03 | 1 | 0.03 |

Notes:
cfs = cubic feet per second
[1] For a lake the dilution weight is based on the sum of the average annual flows for the surface water body entering the lake (Ref. 1, Sec. 4.1.2.3.1).

The zone of Level II contamination in Rio Paguate extends 27,800 feet from samples RM-JM-SW/SED and RP-JM-SW/SED to the farthest downstream sample location, PR-SW/SED-01 (Section 4.1.2.1.1). Rio Paguate and the Paguate Reservoir (Mesita Dam) are fished for catfish, bluegill, and crappie according to the Pueblo of Laguna Environmental and Natural Resources Department, and these fish are caught for human consumption (Ref. 23, p. 1; Ref. 40, p. 1). Data to estimate pounds of fish caught annually for Rio Paguate and Paguate Reservoir are not available; however, because these water bodies are fished, the annual production is known to be greater than zero. As such, a human food chain population value of 0.03 is assigned from Table 4-18 of the HRS (Ref. 1, Table 4-18). Sampling data collected from the EPA March 2010 and April 2011 sampling events document Level II contamination in both the Rio Paguate and the Paguate Reservoir (Ref. 1, Section 4.1.3.3.2.2; Ref. 20, pp. 22, 75, 76, 565, 566, 711, 714, 771, 775, 1185, 1191).

Rio Paguate/Paguate Reservoir - Product of $P_i \times D_i = 0.03 \times 1$

Product of $P_i \times D_i$: 0.03

Level II Concentrations Factor Value: 0.03

### 4.1.3.3.2.3 Potential Human Food Chain Contamination

| Identity of Fishery | Annual Production (pounds) | Type of Surface Water Body | Average Annual Flow | Reference | Population Value ($P_i$) | Dilution Weight ($D_i$) | $P_i$ x $D_i$ |
|---|---|---|---|---|---|---|---|
| Rio San Jose | >0, but unknown | Minimal stream | Less than 10 cfs | Ref. 1, Tables 4-13, 4-18; Ref. 15, pp. 1, 4, 5 | 0.03 | 1 | 0.03 |
| Paguate Reservoir (southern portion) | >0, but unknown | Lake | Less than 10 cfs[1] | Ref. 1, Tables 4-13, 4-18; Ref. 15, pp. 1 to 3 | 0.03 | 1 | 0.03 |

Notes:
cfs = cubic feet per second.
[1] For a lake the dilution weight is based on the sum of the average annual flows for the surface water body entering the lake (Ref. 1, Sec. 4.1.2.3.1).

Rio San Jose and the southern portion of the Paguate Reservoir are fished for catfish, bluegill, and crappie according to the Pueblo of Laguna Environmental and Natural Resources Department; these fish are caught for human consumption (Ref. 23; Ref. 41). Data to estimate pounds of fish caught annually for Rio San Jose and Paguate Reservoir are not available; however, because this water body is fished, the annual production is known to be greater than zero. As such, a human food chain population value of 0.03 is assigned from Table 4-18 of the HRS (Ref. 1, Table 4-18). For Rio San Jose, the dilution weight was based on the average annual flow data collected by the USGS at a gauging station located at Grants, New Mexico (Ref. 15, pp. 1, 4, 5). Based on the stream flow, Rio San Jose, according to Table 4-13 of the HRS, is classified as a minimal stream and receives an assigned dilution weight of 1 (Ref. 1, Table 4-13).

For the southern portion of the Paguate Reservoir, the dilution weight was based on the sum of the average annual flows for the surface water body entering the lake. Since the Paguate flows into the Paguate Reservoir, the average annual flow for the Rio Paguate was also used for the southern portion of the Paguate Reservoir (Ref. 1, Tables 4-13, 4-18; Ref. 15, pp. 1-3). A dilution weight of 1 was also assigned to the Paguate Reservoir in accordance with Table 4-13 of the HRS (Ref. 1, Table 4-13).

Rio San Jose/Paguate Reservoir - Product of $P_i$ x $D_i$ = 0.03 x 1

Product of $P_i$ x $D_i$: 0.03

(Sum of Products of $P_i$ x $D_i$)/10: 0.003

## 4.2 GROUND WATER TO SURFACE WATER MIGRATION COMPONENT- NOT SCORED

Section 4.2 of the HRS states that the ground water to surface water component can be used to evaluate surface water threats that result from migration of hazardous substances from a source at the facility to surface water (Ref. 1). Ground water in the Jackpile Sandstone interchanges with water in the Rio Moquino and Rio Paguate through unconsolidated alluvium deposits along the steam channels. The ground water to surface water component is presented in this section although the surface water likelihood and potential to release as well as the threat-targets are scored based on the overland/flood migration component as shown in Section 4.1 of this report. Since the threat of release by overland flow or flood is more than minimal for this facility and the component score sufficient to score the overall site, this information is presented as supporting information.

In April 2011 an ESI was conducted on behalf of EPA Region 6. The ESI sampling included the collection of ground water, surface water, and surface sediments that were submitted to an EPA-approved laboratory for general water quality analyses (metals, anions, TDS), as well as radionuclides. Field water quality measurements, including pH, temperature, specific conductivity, dissolved oxygen, and Oxidation-Reduction Potential, were collected at the time each sample was collected. Ground water elevation measurements were also collected from a wider suite of wells to gain a better understanding of the overall ground water system (Ref. 35, p. 2794). Based on data culled from several hydrologic studies from 1979 to the present, as well as the results of the 2011 ESI, a CSM was completed in July 2011 (Ref. 35, p. 2794). The ground water and surface water systems of the facility may be described as follows:

• Hydrologic data indicate that both surface water and ground water flow from east-northeast to west-southwest in the western half of the study area, and from north to south in the eastern half of the study area (Ref. 35, p. 2740).
• General cation/anion chemistry identifies two distinct populations of water – one is a sodium + potassium – bicarbonate-sulfate water that is associated with the Jackpile Sandstone, and the other is a calcium + magnesium – carbonate-bicarbonate-sulfate water associated with the Alluvial Aquifer and surface water systems. Strong similarities between the surface water and alluvial ground water strongly suggest that these populations are in intimate contact across the facility (Ref. 35, p. 2740).
• Uranium concentrations/activities increase with respect to background in both ground water and surface water across the facility. This is demonstrated in the results of the 2011 ESI sampling event, as well as at least four studies involving surface water, and two studies involving ground water ( (Ref. 35, p. 2794).
• Ground water, surface water, and sediment samples collected on-site and downgradient of the facility have uranium activities that are significantly elevated with respect to background above the property (Ref. 35, p. 2783).

The hydrologic system of the Jackpile-Paguate Mine includes surface water, and ground waters of the Jackpile Sandstone, Alluvial Aquifer, and waters of the backfilled Paguate and Jackpile pits. Hydrologic studies indicate that these reservoirs interact with each other in a fairly complicated manner based on surface water flow rates and the hydraulic conductivities of the reservoirs where they are in contact with one another (Ref. 35, pp. 2772, 2789).

Mining activities have historically lowered ground water elevations in the upgradient areas of the facility, but not the downgradient areas. The cessation of mining activities, as well as the backfilling of the Paguate and Jackpile pits, has caused the ground water system to rebound. This rebound was predicted before the pits were backfilled; however, the rate of ground water rebound appears to be faster for the South Paguate Pit than anticipated. The models predict that ground water accumulating

in the pits will flow through the natural (Jackpile and Alluvium) geologic materials, as well as waste rock and tailings, to flow into the surface water system (Ref. 25, p. 2773).

Geologic cross sections completed through the facility indicate that surface water may have flowed into the North and South Paguate pits, causing ground water to rebound more quickly than modeled. Ground water elevations indicate that ground water from the North Paguate and Jackpile pits is flowing into Rio Moquino. Ground water from the South Paguate Pit appears to be flowing into Rio Paguate, and water from Rio Paguate (and/or the associated Alluvial Aquifer) may be flowing into the North Paguate Pit (Ref. 35, pp. 2767, 2773).

Historical hydrologic data establish that there is hydrologic communication between surface water and both natural ground water reservoirs (Alluvial and Jackpile) at the facility. This observation is based on ground water and surface water elevation data, aquifer pump tests, and hydrologic modeling. Cross sections using historical and recent hydrologic data also support this observation (Ref. 35, p. 2740).

The hydrologic models also predict hydrologic communication between backfilled pits and the surface water – ground water system. Ground water is predicted to flow from the North Paguate and Jackpile pits into the Alluvial Aquifer, then into the Rio Paguate. Ground water from the South Paguate Pit is predicted to flow into the Jackpile Sandstone and the Alluvial Aquifer, with some fraction reaching Rio Paguate. This prediction is bolstered by the fact that ground water levels in several of the wells near the pits have increased up to 66 feet in the last 30 years. The rebound of the water table is due partially to the fact that mining activities, specifically pumping of water from the pit areas, ceased in 1982. Cross sections drawn through the pits illustrate the relationship between the excavated and backfilled pit conditions with respect to the most dramatically affected wells (Ref. 35, p. 2789).

Field measurements and laboratory analysis of the ground water in the Jackpile, North Paguate, and South Paguate pits indicate that chemical reactions are occurring in the backfill that mobilize uranium in very high concentrations (four to five orders of magnitude higher than background surface or ground water). Ground water in the pits appears to be rebounding at a rate much higher than pre-remedial modeling predicted; ground water in the South Paguate Pit has already rebounded 10 feet above the elevation it was projected to reach after 150 years. Hydrologic observations and modeling indicate that these pit waters are not contained and will flow into the surface water system via ground water pathways, carrying contaminants into that system (Ref. 35, p. 2795).

Ground water sampling was performed as part of the April 2011 sampling activities. Analytical data from this sampling event indicated the presence of hazardous substances similar to those found in the scored sources and observed release samples evaluated for this site. Information from the April 2011 activities are presented in the following tables and paragraphs.

## Ground Water Release Sampling Locations

| Station Location | Sampling Location | Sample Date (Military Time) | Reference |
|---|---|---|---|
| **EPA ESI Ground Water Sampling – April 2011** | | | |
| MW-2 | Monitoring well location just south and downgradient of Jackpile-Paguate mine. | 4/21/11 (1023) | Ref. 35, pp. 81 ,119; Figure A-5B |
| MW-2-2 | Monitoring well location just south and downgradient of Jackpile-Paguate mine (duplicate). | 4/21/11 (1028) | Ref. 35, pp. 81, 119; Figure A-5B |
| MW-3 | Monitoring well located within the Jackpile-Paguate mine along the north side of Rio Paguate. | 4/20/11 (1415) | Ref. 35, pp. 78, 119; Figure A-5B |
| MW-4 | Monitoring well located within the Jackpile-Paguate mine along the south side of Rio Paguate. | 4/20/11 (1333) | Ref. 35, pp. 77-78, 119; Figure A-5B |
| MW-6 | Monitoring well located south and downgradient of mine. | 4/20/11 (1153) | Ref. 35, pp. 77, 119; Figure A-5B |
| MW-MD | Monitoring well located downgradient of Jackpile-Paguate mine and west of Mesita Dam. | 4/20/11 (1030) | Ref. 35, pp. 76-77, 119; Figure A-5B |
| MW-MD-02 | Monitoring well located downgradient of Jackpile-Paguate mine and west of Mesita Dam (duplicate). | 4/20/11 (1030) | Ref. 35, pp. 76-77, 119; Figure A-5B |

Background and characterization samples were collected by START-3 on 19 through 21 April 2011 (Ref. 35, pp. 72-82; Ref. 36, p. 4). The samples were collected and transferred to approved sample containers in accordance with the approved QASPs (Ref. 8, p. 13; Ref. 36, p. 4). The ground water samples were collected using low flow sampling techniques and either a pneumatic pump or a bailer (Ref. 35, p. 113; Ref. 35 pp. 72-82).

The samples were analyzed using established EPA methodologies and laboratory Standard Operation Procedures (SOPs). The April 2011 samples were hand delivered to Summit Laboratory, located in Albuquerque, New Mexico on 22 April 2011 (Ref. 36, p. 4). The samples were analyzed for: isotopic uranium (isotopes 234, 235, and 238) by method Eichrom ACW-03-15 and ACW-10; total metals by EPA method 200.7 for water and 6010B for solids; selenium by EPA method 6020; mercury by EPA method 7470A/7471A; Radium$^{226}$ by EPA method 903; and Radium$^{228}$ by EPA method 904. In addition, all water samples were also analyzed for: alkalinity by method SM2310-B; bicarbonate by method SM-17 2320; carbonate by method SM 4500-CO2D; Total Dissolved Solids by method SM 2540-C; and anions by EPA method 300 (Ref. 36, pp. 5).Once final analytical results were received, the data underwent third-party data review and validation by a START-3 chemist not associated with the sampling conducted at the facility (Ref. 25; Ref. 36, p. 5).

## Ground Water Background Sample Concentrations

| Station Location | Hazardous Substance | Concentration | Units[1] | Reference |
|---|---|---|---|---|
| MW-1 | $Uranium^{234}$<br>$Uranium^{235}$<br>$Uranium^{238}$<br>$Radium^{228}$ | 3.74<br>0.161<br>0.826<br>1.26 | pCi/l<br>pCi/l<br>pCi/l<br>pCi/l<br>pCi/l | Ref. 35, pp. 374, 756, 1587 |
| MW-7-110419 | $Uranium^{234}$<br>$Uranium^{235}$<br>$Uranium^{238}$<br>$Radium^{226}$<br>$Radium^{228}$ | 3.80<br>0.062<br>0.44<br>2.71<br>1.11 | pCi/l<br>pCi/l<br>pCi/l<br>pCi/l<br>pCi/l<br>pCi/l | Ref. 35, pp. 377, 764, 1587 |
| MW-8-110419 | $Uranium^{234}$<br>$Uranium^{235}$<br>$Uranium^{238}$ | 5.21<br>0.059<br>1.95 | pCi/l<br>pCi/l<br>pCi/l | Ref. 35, pp. 765, 1587 |
| MW-RM | $Uranium^{234}$<br>$Uranium^{235}$<br>$Uranium^{238}$ | 11.6<br>0.733<br>30.0 | pCi/l<br>pCi/l<br>pCi/l | Ref. 35, pp. 780, 1587 |

Notes:
[1] pCi/l – picocurie per liter

## Ground Water Non-Radioactive Characterization Sample Concentrations

| Station Location | Hazardous Substance | Concentration | Reporting Limit[1] | Units[2] | Reference |
|---|---|---|---|---|---|
| **EPA ESI – April 2011[3]** | | | | | |
| MW-2-110421 | Manganese | 0.275 | 0.00043 | mg/l | Ref. 35, pp 81, 341, 1527, 1534 |
| MW-2-2-110421 | Manganese | 294 | 0.430 | mg/l | Ref. 35, pp. 81 , 342, 1527, 1534 |
| MW-4-110420 | Manganese | 32.4 | 0.43 | mg/l | Ref. 35, pp. 77-78, 344, 1527, 1534 |
| MW-MD-110420 | Manganese | 654 | 0.43 | mg/l | Ref. 35, pp. 76-77, 349, 1527, 1534 |
| MW-MD-02-110420 | Manganese | 693 | 0.43 | mg/l | Ref. 35, pp. 76-77, 348, 1527, 1534 |

Notes:
[1] The Reporting Limit is defined as the LOD for the April 2011 data provided by Summit Analytical Laboratories. The LOD is equal to the Laboratory Detection Limit which is adjusted for dilution factors (Ref. 35, p. 337). [2] ppb – parts per billion = microgram per liter (ug/l), pCi/l = picocurie per liter
[2] mg/l – milligram per liter
[3] Chemical laboratory data collected during EPA SI and ESI activities were validated by a START-3 chemist in accordance with *EPA USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review* (July 2002), and the Regional Protocol for Holding Times, Blanks, and VOA Preservation (April 13, 1989). Data for target analytes meet the definitive data quality objective (Ref. 25, pp. 5, 36, 49, 74).

## Ground Water Radioactive Characterization Sample Concentrations

| Station Location | Hazardous Substance | Concentration | Reporting Limit[1] | Units[2] | Reference |
|---|---|---|---|---|---|
| **EPA ESI – April 2011[3]** | | | | | |
| MW-2-110421 | $Uranium^{234}$ | 63.5 | 0.051 | pCi/l | Ref. 35, pp 81, 757 , 1587 |
| | $Uranium^{235}$ | 2.23 | 0.012 | pCi/l | |
| | $Uranium^{238}$ | 54.2 | 0.042 | pCi/l | |
| MW-2-2-110421 | $Uranium^{234}$ | 62.7 | 0.054 | pCi/l | Ref. 35, pp. 81 , 758, 1587 |
| | $Uranium^{235}$ | 2.49 | 0.033 | pCi/l | |
| | $Uranium^{238}$ | 54.4 | 0.035 | pCi/l | |
| MW-3-110420 | $Uranium^{234}$ | 17.7 | 0.046 | pCi/l | Ref. 35, pp. 78, 1587 |
| MW-4-110420 | $Uranium^{234}$ | 119 | 0.038 | pCi/l | Ref. 35, pp. 77-78, 762, 1587 |
| | $Uranium^{235}$ | 4.58 | 0.011 | pCi/l | |
| | $Uranium^{238}$ | 108 | 0.038 | pCi/l | |
| MW-6-110420 | $Uranium^{234}$ | 73.2 | 0.010 | pCi/l | Ref. 35, pp. 77, 763, 1587 |
| | $Uranium^{235}$ | 2.62 | 0.011 | pCi/l | |
| | $Uranium^{238}$ | 61.8 | 0.050 | pCi/l | |
| MW-MD-110420 | $Uranium^{234}$ | 31.3 | 0.036 | pCi/l | Ref. 35, pp. 76-77, 767, 1587 |
| | $Uranium^{235}$ | 1.00 | 0.033 | pCi/l | |
| MW-MD-02-110420 | $Uranium^{234}$ | 29.1 | 0.185 | pCi/l | Ref. 35, pp. 76-77, 766, 1587 |
| | $Uranium^{235}$ | 1.06 | 0.091 | pCi/l | |

Notes:
[1] Reporting Limit is the MDC which is the net concentration that has a specified chance of being detected (Ref. 39, p. 3).
[2] pCi/l - picocurie per liter
[3] Radiological data were validated by a START-3 Certified Health Physicist with 30 years of radiation characterization experience. Data for target analytes meet the definitive data quality objective (Ref. 35, p. 1587; Ref. 36, p. 5).

The ground water and surface water samples both contain the same contaminants, further bolstering the interaction between the pathways. $Uranium^{234}$, $uranium^{235}$, $uranium^{238}$, and manganese were found at concentrations exceeding established background concentrations within ground water and surface water samples. If this analytical data were to be used to establish an observed release by chemical analysis, Level II concentrations of $uranium^{234}$, $uranium^{235}$, $uranium^{238}$, and manganese would be established in Rio Moquino and Rio Paguate to a distance of 27,800 feet from samples RM-JM-SW and RP-JM-SW to the Paguate Reservoir (as defined by Level II surface water sample location PR-SW-01) (refer to Section 4.0 and Figure A-3A).

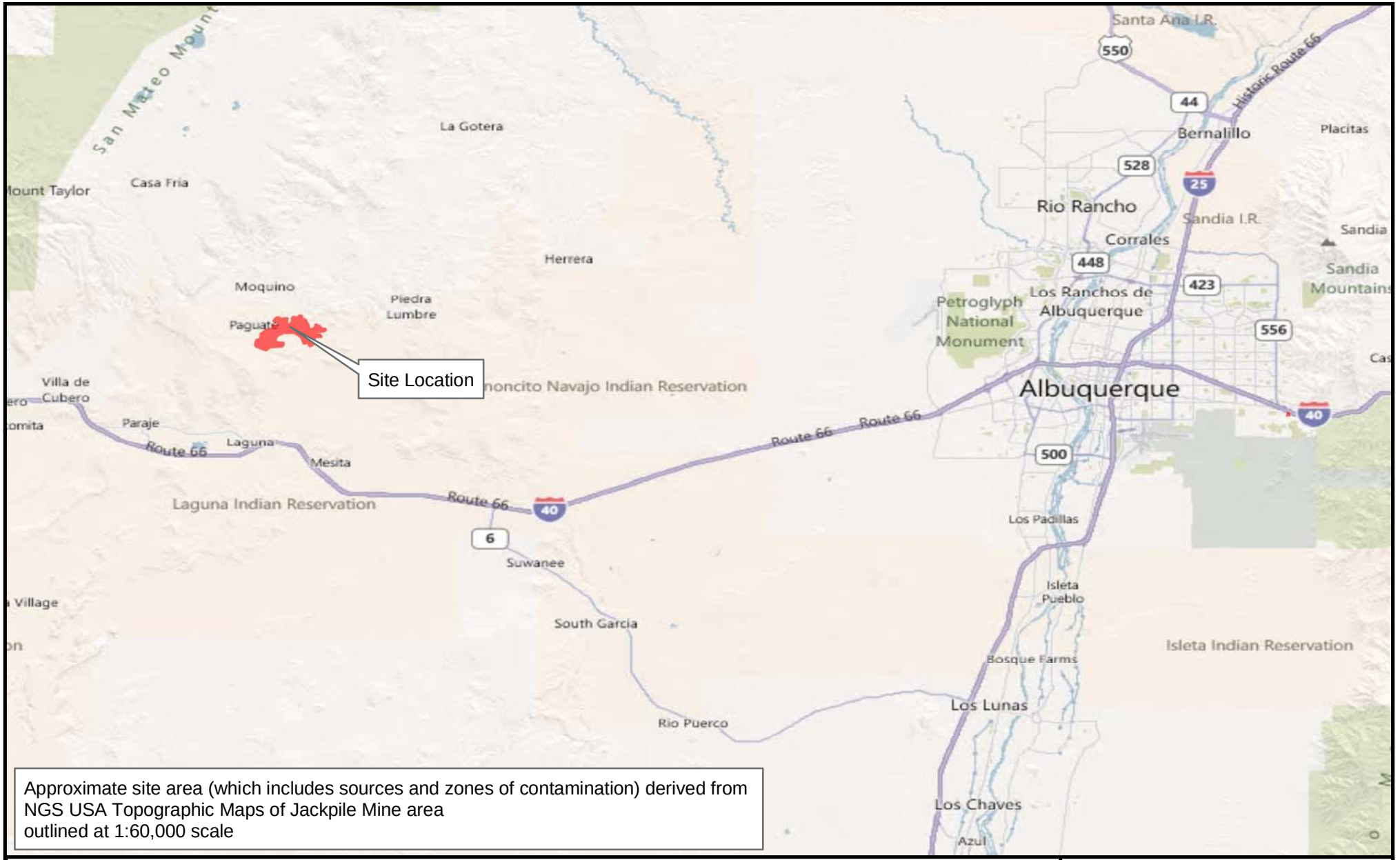
## 5.0 SOIL EXPOSURE PATHWAY SCORE - NOT SCORED

The soil exposure pathway will not be scored because it would not significantly affect the overall site score. Further, the site score exceeds 28.50 based only on the evaluation of the surface water pathway.

## 6.0 AIR MIGRATION PATHWAY SCORE - NOT SCORED

The air migration pathway will not be scored because it would not significantly affect the overall site score. Further, the site score exceeds 28.50 based only on the evaluation of the surface water pathway.

# Attachment A




**LEGEND**

Approximate Mine Area

0 10 20

SCALE IN MILES

New Mexico

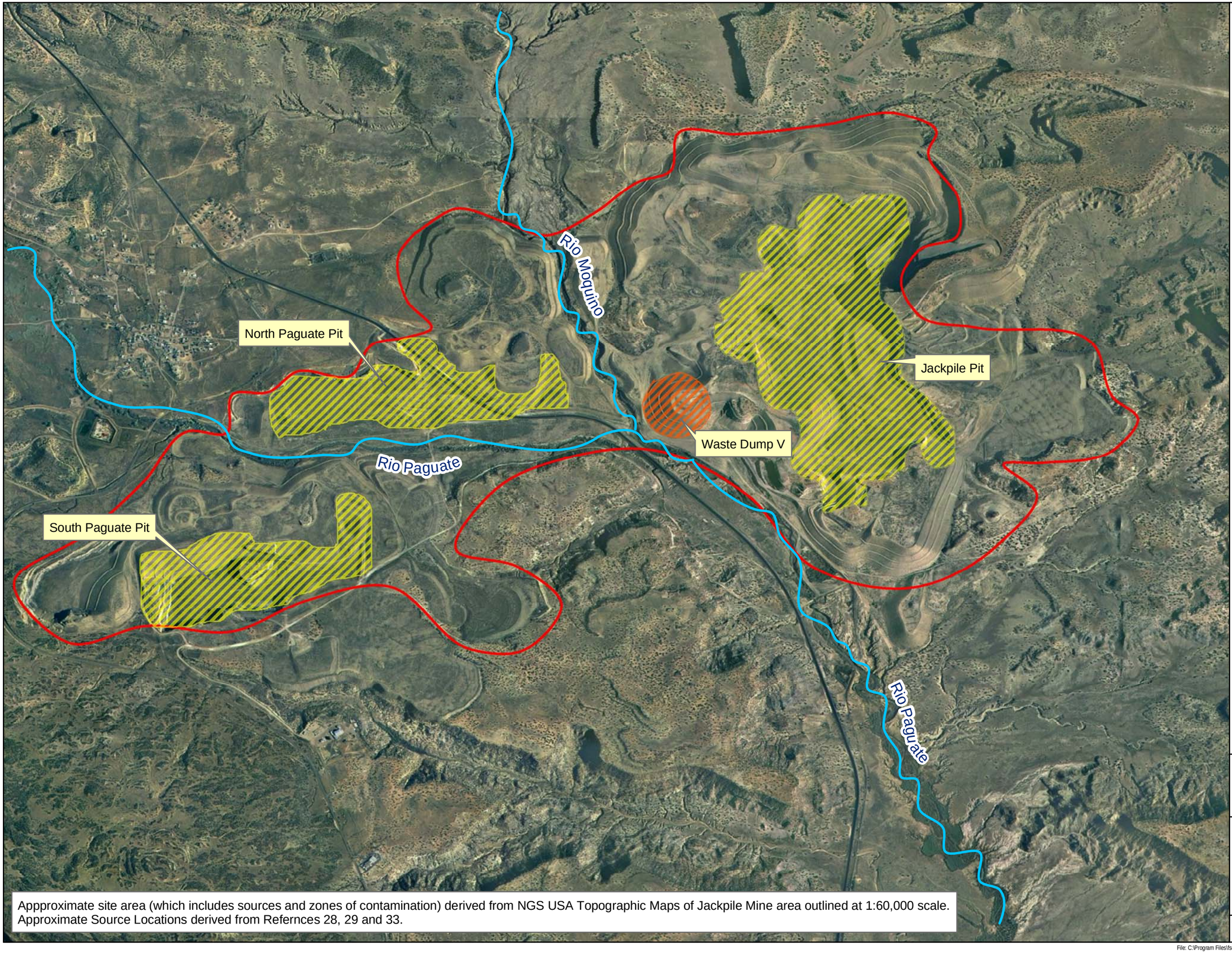
N

Source: Microsoft Virtual Earth Roads, 2009
CERCLIS: NMN000607033
SSID: A6T3
TDD: TO-0019-10-02-02

**USEPA REGION 6**
**START - 3**

**FIGURE A-1**
SITE LOCATION MAP
JACKPILE-PAGUATE URANIUM MINE
SR 279 Laguna Pueblo
Paguate, Cibola County, New Mexico

| DATE | PROJECT NO | SCALE |
|---|---|---|
| MAY 2010 | 20406.012.019.0514.01 | AS SHOWN |




Appproximate site area (which includes sources and zones of contamination) derived from NGS USA Topographic Maps of Jackpile Mine area outlined at 1:60,000 scale.
Approximate Source Locations derived from Refernces 28, 29 and 33.


**LEGEND**

- Approximate Mine Boundary
- River
- Waste Dump
- Open Pit

N

0 0.4 0.8

SCALE IN MILES

TDD NO: TO-0019-10-02-02
CERCLA NO: NMN000607033
SSID: A6T3

SOURCE: Microsoft Virtual Earth Roads, 2009

DISCLAIMER: THIS FIGURE IS PREPARED FOR REFERENCE PURPOSES ONLY AND SHOULD NOT BE USED, AND IS NOT INTENDED FOR, SURVEY OR ENGINEERING PURPOSES.

USEPA REGION 6
START-3

# FIGURE A-2
## SITE LAYOUT MAP
## JACKPILE-PAGUATE URANIUM MINE
## SR 279 Laguna Puablo

Paguate, Cibola County, New Mexico

| DATE | PROJECT NO | SCALE |
|---|---|---|
| OCT 2011 | 20406.012.019.0514.01 | AS SHOWN |

File: C:\Program Files\fsdx03\IT\TGIS_Projects\brownm\Jackpile\HRS\Figure A-2)101411.mxd, 14-October 2011, brownm

Waste Dump V

Paguate Lake

North Paguate Pit

RP-JM-SW

RM-JM-SW

Jackpile Pit

PPE 1

PPE 2

PPE 3

PPE 4

RP-JM-SW-01

South Paguate Pit

RP-SW-01

RP-SW-02

Level II Documented Fishing Area

Rio Paguate

RP-SW-03

Mesita Dam

PR-SW-01

Paguate Reservoir

Potential Documented Fishing Area

Rio San Jose

Appproximate site area (which includes sources and zones of contamination) derived from NGS USA Topographic Maps of Jackpile Mine area outlined at 1:60,000 scale.
Approximate Source Locations derived from Refernces 28, 29 and 33.

New Mexico

**LEGEND**

- Approximate Mine Boundary
- River
- Probable Point of Entry (PPE)
- Level II Sample Locations
- Waste Dump
- Open Pit
- Overland Flow Direction
- Level II Documented Fishery
- Potential Documented Fishery
- Target Distance Limit (TDL)
- Surface Water Flow Direction

N

0 1.5 3

SCALE IN MILES

TDD NO: TO-0019-10-02-02
CERCLA NO: NMN000607033
SSID: A6T3

SOURCE: NGS USA Topographic Maps

DISCLAIMER: THIS FIGURE IS PREPARED FOR REFERENCE PURPOSES ONLY AND SHOULD NOT BE USED, AND IS NOT INTENDED FOR, SURVEY OR ENGINEERING PURPOSES.

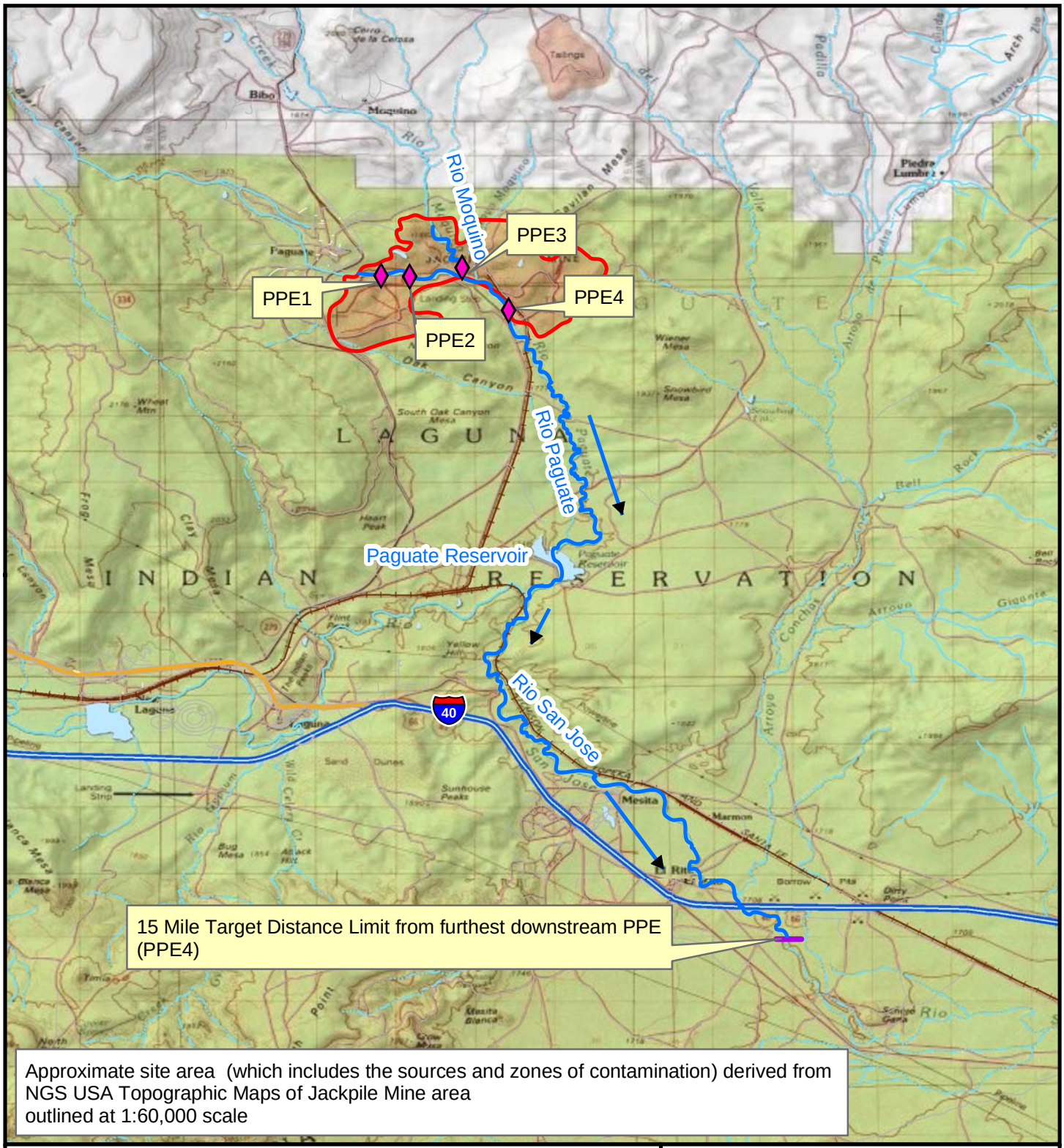
USEPA REGION 6
START-3

FIGURE A-3
SURFACE WATER PATHWAY MAP
JACKPILE-PAGUATE URANIUM MINE
SR 279 Laguna Puablo

Paguate, Cibola County, New Mexico

| DATE | PROJECT NO | SCALE |
|---|---|---|
| OCT 2011 | 20406.012.019.0514.01 | AS SHOWN |

File: C:\Program Files\fsdtx03\I\T\TGIS_Projects\brownm\Jackpile\HRS\Figure A-3_101411.mxd, 14-October 2011, brownm

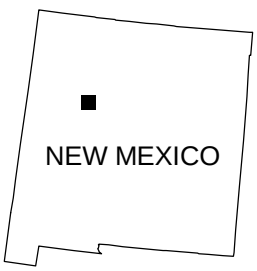



**LEGEND**

- Approximate Mine Boundary
- Probable Point of Entry (PPE)
- Surface Water (SW) Pathway
- Target Distance Limit (TDL)
- Flow Direction

0 2.5 5

SCALE IN MILES




N

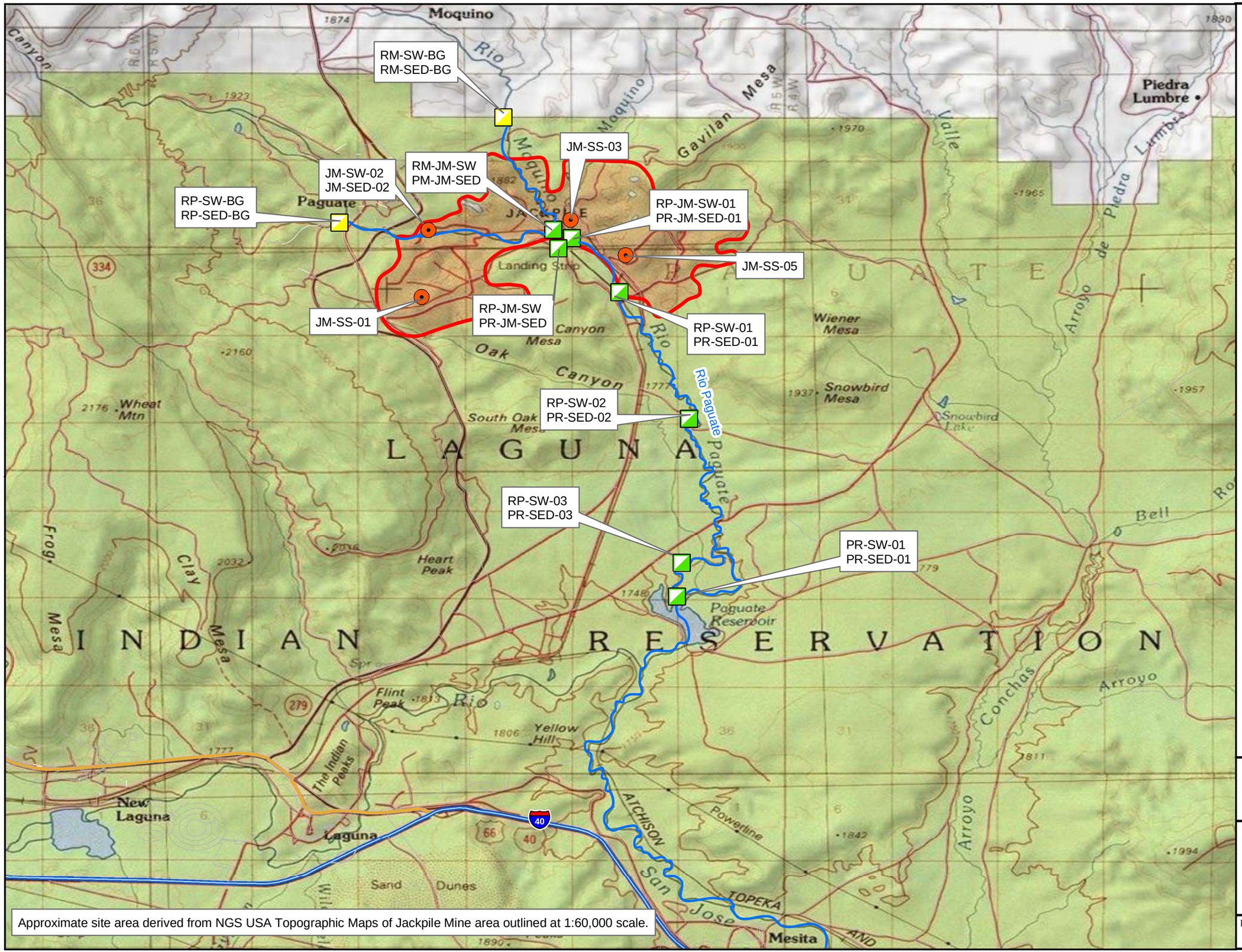
Source: NGS USA Topographic Maps
CERCLIS: NMN000607033
SSID: A6T3
TDD: TO-0019-10-02-02

**USEPA REGION 6**
**START-3**

**FIGURE A-4**
15-MILE TARGET DISTANCE LIMIT
JACKPILE-PAGUATE URANIUM MINE
SR 279 Laguna Pueblo
Paguate, Cibola County, New Mexico

| DATE | PROJECT NO | SCALE |
|---|---|---|
| JUNE 2010 | 20406.012.001.0222.01 | NOT TO SCALE |

File: \\fsdtx03\IT\GIS_Projects\brownm\Jackpile\HRS\Figure A-4, 23-September-2011, brownm





**LEGEND**

- Approximate Mine Boundary
- Surface Water (SW) Pathway
- SW and Sediment Sample Location
- SW and Sediment Background Sample Location
- Source Sample Location
- RP — Sample Name

N

0 250 500

SCALE IN MILES

Source: NGS USA Topographic Maps
CERCLIS: NMN000607033
SSID: A6T3
TDD: TO-0019-10-11-01

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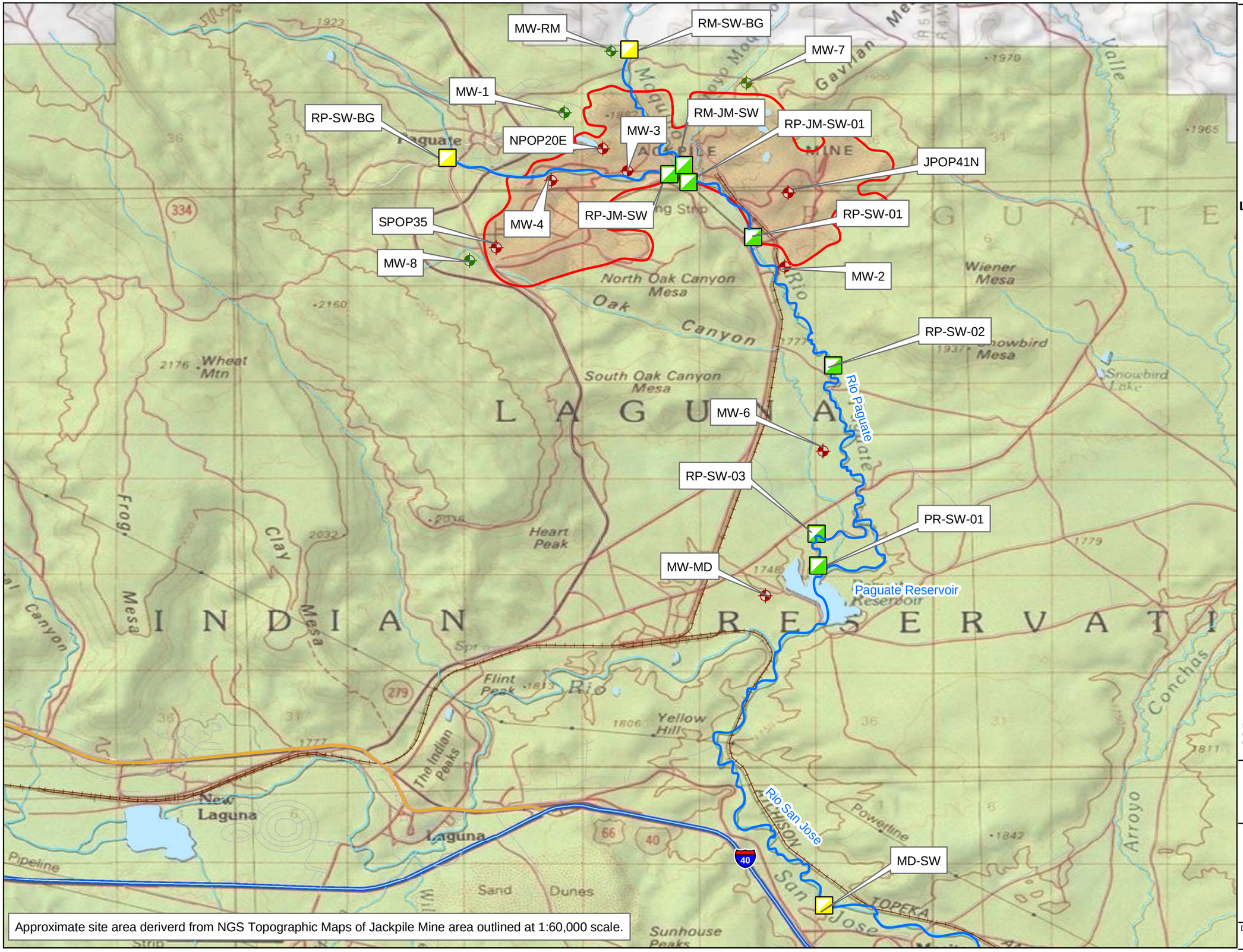
**USEPA REGION 6**
**START-3**

FIGURE A-5A
SITE INSPECTION
SAMPLE LOCATION MAP
JACKPILE-PAGUATE URANIUM MINE
SR 279 Laguna Pueblo

Paguate, Cibola County, New Mexico

| DATE | PROJECT NO | SCALE |
|---|---|---|
| OCT 2011 | 20406.012.019.0514.01 | AS SHOWN |

File: \\fsdfx03\T\GIS_Projects\brownm\Jackpile\HRS\Figure A-5A.mxd, 18-October-2011





**LEGEND**

- Approximate Mine Boundary
- Surface Water (SW) Pathway
- SW and Sediment Sample Location
- Monitoring Well Sample Location
- SW and Sediment Background Sample Location
- Monitoring Well Background Sample Location
- RP — Sample Name

N

0 1 2

SCALE IN MILES

Source: NGS USA Topographic Maps
CERCLIS: NMN000607033
SSID: A6T3
TDD: TO-0019-10-11-01

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USEPA REGION 6
START-3

# FIGURE A-5B
# EXPANDED SITE INSPECTION
# SAMPLE LOCATION MAP
# JACKPILE-PAGUATE URANIUM MINE ESI

SR 279 Laguna Pueblo

Paguate, Cibola County, New Mexico

| DATE | PROJECT NO | SCALE |
|---|---|---|
| JULY 2011 | 20406.012.019.0603.01 | AS SHOWN |

File: \\fsdtx03\IT\GIS_Projects\brownm\Jackpile\Figure 3-1, 8-March-2011, brownm